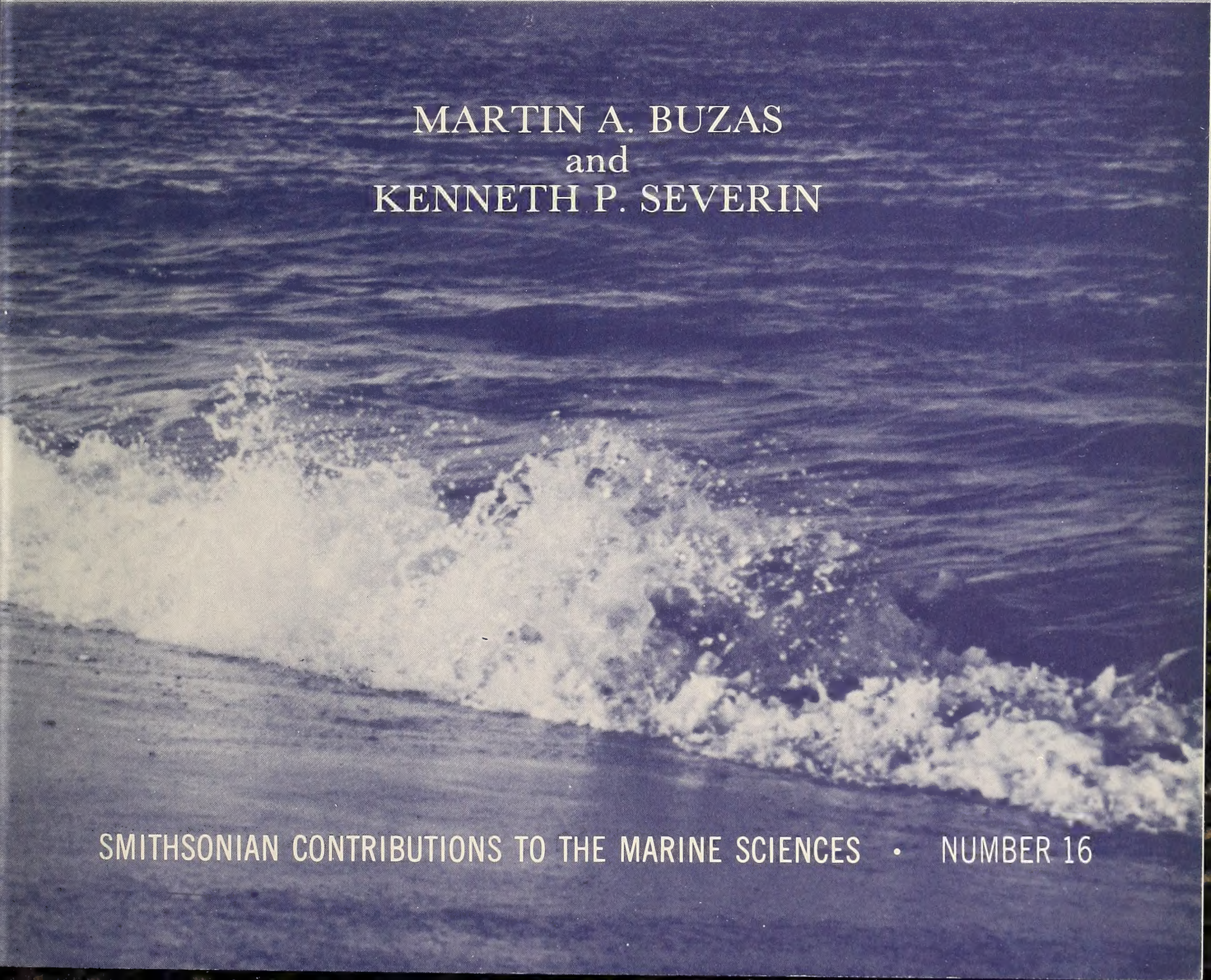
Distribution and Systematics of Foraminifera in the Indian River, Florida

MARTIN A. BUZAS
and
KENNETH P. SEVERIN



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ABSTRACT

Buzas, Martin A., and Kenneth P. Severin. Distribution and Systematics of Foraminifera in the Indian River, Florida. *Smithsonian Contributions to the Marine Sciences*, number 16, 73 pages, 25 figures, 6 tables, 11 plates, 1982.—The Indian River, a shallow, 195 km long estuary, is bounded on the east by a barrier island. Three inlets divide the barrier island, providing exchange with the Atlantic Ocean. Twelve areas covering the length of the estuary were sampled for living foraminifera. Altogether, 17,348 individuals belonging to 94 species were identified. The mean number of individuals and the number of species generally increase from north to south.

The densities of the 15 most abundant species, comprising 95% of the total number of living individuals, were analyzed by canonical variate analysis. The first canonical axis discriminated the inlets and the northernmost (Haulover) area from the rest. On the second canonical axis, the 12 areas were arranged in a north-to-south series. Examination of the data confirms that the analysis succinctly summarizes foraminiferal distribution in the Indian River.

Taxonomic notes are given for each species, and almost all species are illustrated. *Ishamella apertura*, new genus and species, is described and illustrated.

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Distribution and Systematics of Foraminifera in the Indian River, Florida

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Introduction

The Indian River, a shallow, 195 km long body of water on the east-central coast of Florida (Figure 1), is a euryhaline and eurythermal estuary. Bounded on the east by a barrier island, the southern half of the estuary is connected with the Atlantic Ocean by three inlets: Sebastian, Fort Pierce (Jim's Flat of this study), and St. Lucie. All the inlets are maintained artificially. The northern end of the estuary is connected to the ocean via Haulover Canal, which links the estuary to the Mosquito Lagoon and the Ponce de Leon Inlet 40 km farther north.

The average depth of the Indian River is about 1.5 m; the greatest depths, about 3.5 m, occur in the Intracoastal Waterway and other dredged boat channels. The substrate is quartz sand with a low percentage of silt and clay. Because of the shallow depths, the waters of the estuary are influenced by a combination of tidal flushing, surface drainage, rainfall, and wind conditions.

Near the inlets, estuarine water is exchanged with the Atlantic Ocean on a semidiurnal basis and has little variation in salinity and only seasonal differences in temperature (Table 1). In the portions of the river away from the inlets, however, the tidal influence is almost negligible, and conditions are determined by nontidal effects. In general, the range of variation in temperature and salinity decreases from north to south (Table 1), whereas the average increases. An overall gradient of decreasing environmental variability from north to south was pointed out by Young et al. (1976), Young and Young (1977), and Nelson et al. (1982).

Although the foraminifera of the bays and estuaries of the northeastern continental margin of North America are relatively well studied, very little information exists from the shallower waters of the southeastern portion of the continent (Culver and Buzas, 1980). The purpose of the present investigation is to document the distribution and systematics of the foraminifera from the major estuary in east-central Florida.

Acknowledgments.—We thank M. Abrams, R. Bronson, K. Carle, M. Cavanaugh, G. Heim, A. Lanham, C. Leibhauser, C. McCloy, and S. Pohanka for help in the laboratory. The samples were collected by K. Carle, D. Mook, and D. Young. The foraminifera and figures were drawn by Lawrence Isham. J. Piraino operated the SEM, and T. Smoyer assisted greatly in the darkroom. D. Dean prepared specimens for sectioning.

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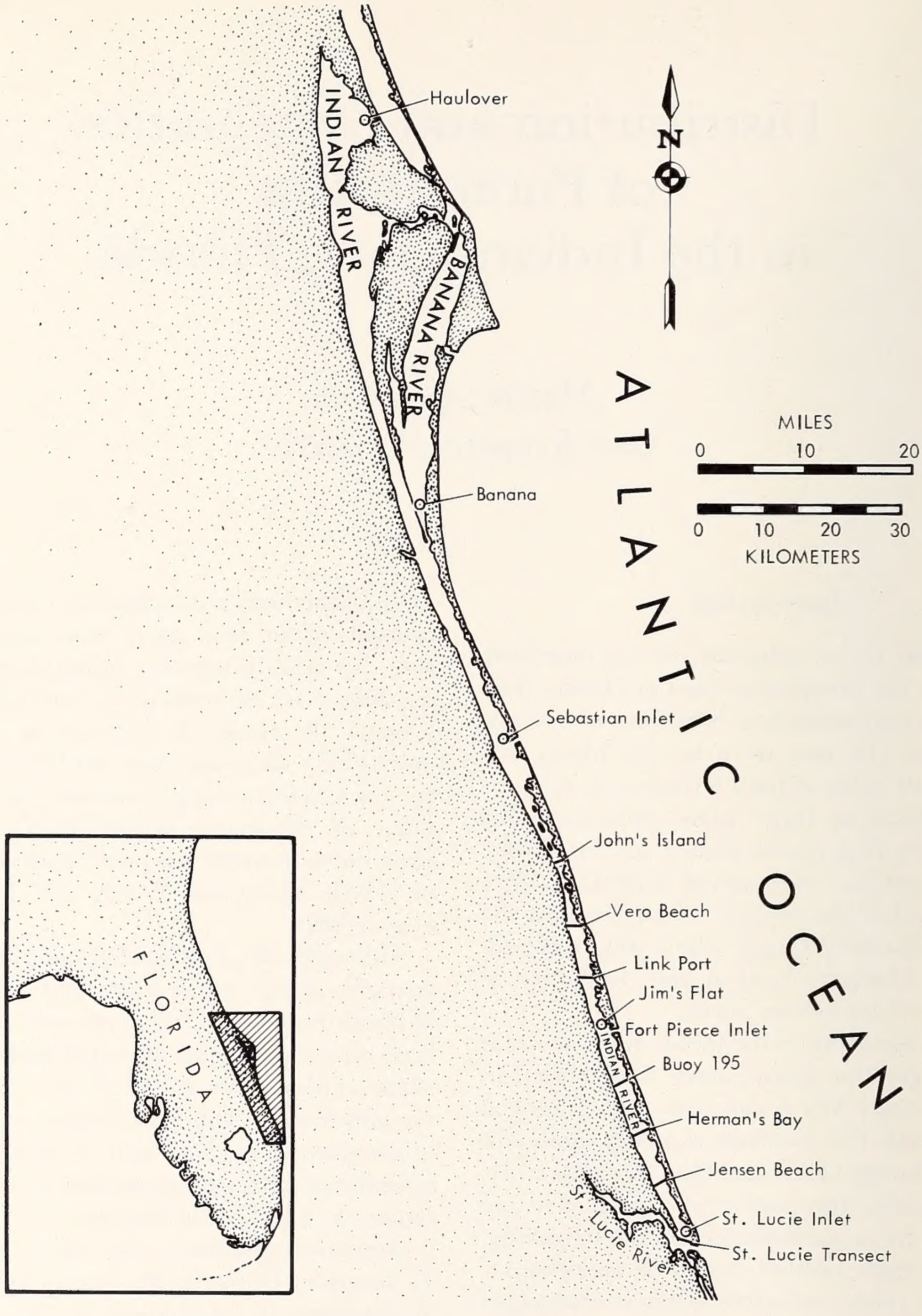

FIGURE 1.—Sampling localities.

C. G. Adams and J. Whittaker provided access to several specimens in the British Museum (NH). D. Dance and H. Marshall assisted in the computer analysis. S. J. Culver provided helpful criticisms of the manuscript, and, finally, we thank June Jones for typing it.

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TABLE 1.—Ranges of temperature and salinity in the Indian River (except where noted, all data are from Nelson et al., 1982)

Location	Temperature (°C)	Salinity (‰)
Haulover	11–34	20–46
Banana	15–35	18–40
Sebastian (Inlet)	14–30	25–36
Vero Beach (Mook, 1980)	15–30	25–35
Link Port	12–32	20–38
Ft. Pierce (Inlet) (Mook, 1980)	17–28	33–34
Herman's Bay (Wilcox and Gilmore, 1977)	14–29	22–32
St. Lucie (Inlet)	18–32	28–36

Methods

SAMPLING PLAN.—The samples for this study were taken in 1975 and 1976. The sampling program consisted of either single stations or stations located along a transect (Figure 1). At each transect station, two replicate cores were taken. One replicate from the John's Island transect was lost. The inlets (Sebastian, Jim's Flat at Fort Pierce, and St. Lucie) and Haulover and Banana consisted of single stations with four replicates. A replicate from the Banana station was lost. Table 2 lists the locations, the number of replicates (or observations), the date of sampling, and the latitude and longitude of each locality.

FIELD METHODS.—Samples were taken by inserting 3.5 cm diameter plastic core liners into the sediment by hand or, in deeper water, by attaching them to a long pole. Upon recovery the samples were fixed with neutralized formalin.

LABORATORY METHODS.—On return to the laboratory, the top 20 ml of sediment was removed from the cores, washed over a 63 μm sieve, and stored in 95% ethanol. Before examination, the sample was stained for about 24 hours with rose bengal, washed once more over a 63 μm sieve, rinsed with acetone, and dried. The sample then was floated twice in a mixture of bromoform and acetone (specific gravity 2.4). The floated portion of the sample was re-wet, and the stained foraminifera was picked out and placed on a micropaleontologic slide for sorting, identification, and enumeration.

STATISTICAL METHODS.—The sampling plan was designed so that replicates were taken at all locations. This allows the data to be analyzed by canonical variate analysis, also called multiple discriminant analysis. The use of this method for faunal analysis was described by Buzas (1967). The computer program used for the analysis is part of the Statistical Package for the Social Sciences (SPSS). All densities were transformed to ln (x+1) before analysis to insure stability of variances and to increase Normality.

For each sampling location, the information function and a measure of equitability were cal-

TABLE 2.—Sampling localities and dates of sampling, listed from north to south

Location	No. of replicates	Date sampled	Latitude/Longitude
Haulover station	4	30 Jun 1975	28°44.1′N/80°45.5′W
Banana station	3	30 Jun 1975	28°12.0′N/80°37.0′W
Sebastian Inlet station	4	26 Jun 1975	27°51.5′N/80°27.6′W
John's Island transect	4 (2 stations)	12 Feb 1976	27°41.6′N/80°23.4′W
	5 (3 stations)	2 Mar 1976	27°41.6′N/80°23.4′W
Vero Beach transect	10 (5 stations)	7 Sep 1977	27°37.1′N/80°22.0′W
Link Port transect	6 (3 stations)	18 Dec 1975	27°32.1′N/80°20.9′W
Jim's Flat (inlet) station	4	25 Jun 1975	27°28.4′N/80°19.0′W
Buoy 195 transect	10 (5 stations)	12 Jan 1976	27°24.2′N/80°17.6′W
Herman's Bay transect	10 (5 stations)	17 Feb 1976	27°19.7′N/80°15.0′W
Jensen Beach transect	10 (5 stations)	22 Apr 1976	27°15.2′N/80°13.1′W
St. Lucie transect	10 (5 stations)	17 Feb 1976	27°10.9′N/80°11.2′W
St. Lucie Inlet station	4	25 Jun 1975	27°11.0′N/80°10.1′W

culated. The information function was calculated from the formula

$$H = -\Sigma p_i \ln p_i,$$

and equability from the formula

$$E = \frac{e^H}{S},$$

where e is the base of the natural logarithms, and S is the number of species (Buzas and Gibson, 1969).

Distribution of Abundant Foraminifera

Of the 94 species recorded in the Indian River, few were abundant. We arbitrarily chose the 15 most abundant species for canonical variate analysis. These 15 species represent about 95% of the total living population. The first analysis was made using each station as a separate group. The results were difficult to interpret, and so we decided on a simpler scheme. Inspection of the data showed little difference among stations in transects; consequently, all stations within transects were treated as a single group. This divided the samples into the 12 groups shown in Figure 1 and Table 2. The number of replicates varies from area to area and also is shown in Table 2. In all, there are N = 83 observations, h = 12 areas, and p = 15 species.

Canonical variate, or multiple discriminant, analysis emphasizes the difference between mean vectors in a p-dimensional space. The first canonical axis is placed as close as possible to the ends of the mean vectors, the second at right angles to the first, and so on. When $p>h$, there are only $h-1$ possible canonical variates. While this reduction in the number of dimensions is advantageous, an even greater advantage is that the first canonical variate will account for most of the variability, the second much less, and so on. In addition, each canonical variate is statistically independent and of unit variance, which greatly facilitates comparison of the results.

In the grouping used, there are $h-1 = 11$ possible eigenvalues. Of these, the first six were significant at the 95% level, using the criterion provided by the SPSS program used for the analysis. These eigenvalues, the percent of the variability accounted for, and their cumulative percent are shown in Table 3.

The first six mean canonical variates are shown in Table 4. Mean canonical variate 1 contrasts Haulover, Sebastian, Jim's Flat, and St. Lucie Inlet against the other areas. In other words, the first mean canonical variate, accounting for 37% of the total variability, indicates that Haulover and the inlets are quite distinct from the other areas. The second canonical variate, accounting for 17% of the total variability, contrasts the northern areas against the southern areas (Table 4). A plot of mean canonical variate 1 vs. mean canonical variate 2 (with 95% confidence circles) is shown in Figure 2. The inlets and Haulover are discriminated clearly from the remaining stations and from one another. The inlets and other areas are also arranged in a north-south pattern, with some areas slightly out of place (Figures 1, 2).

Figures 3 through 17 plot the mean densities of the 15 most abundant species at the 12 areas, and Table 5 lists the mean number of individuals per replicate (20 ml of sediment) plus some other useful statistics. We recall the first canonical variate contrasted Haulover, Sebastian, Jim's Flat, St. Lucie Inlet, and the remaining areas. By examining the canonical discriminate function coefficients (Table 6), we can determine the species mainly responsible for this contrast. In order of importance, these species are: *Gaudryina exilis* (Figure 12), *Cyclogyra planorbis* (Figure 7), *Elphidium gunteri* (Figure 9), *Bolivina striatula* (Figure 5), *Nonionella auricula* (Figure 13), *Rosalina floridana*

TABLE 3.—The first six eigenvalues arranged in decreasing order with the percentage of variability accounted for

Eigenvalue	*Percent of variability*	*Cumulative percent*
4.44	37.36	37.36
2.04	17.20	54.56
1.35	11.37	65.93
1.08	9.06	74.99
1.05	8.87	83.86
0.82	6.93	90.79

TABLE 4.—Mean canonical variates for the first six variates (localities listed from north to south)

Area	*CV 1*	*CV 2*	*CV 3*	*CV 4*	*CV 5*	*CV 6*
Haulover	4.03	−1.32	0.56	−0.89	−1.69	0.14
Banana	−1.00	−2.50	−0.13	0.32	−0.32	1.06
Sebastian	2.01	−1.57	−2.64	1.47	−0.80	−1.00
John's Island	−0.52	−2.04	−0.25	0.95	0.35	0.09
Vero Beach	−1.45	−1.20	0.09	−1.69	0.62	0.60
Link Port	−1.86	0.02	−0.35	−0.74	0.87	−1.80
Jim's Flat	5.15	0.30	1.26	−0.17	0.84	1.08
Buoy 195	−1.49	1.22	−0.17	1.22	0.61	1.13
Herman's Bay	−0.01	0.20	2.12	0.73	0.03	−0.99
Jensen Beach	−0.81	0.87	0.02	−0.02	−1.13	0.05
St. Lucie transect	−0.31	1.63	−0.67	−0.66	−1.07	0.06
St. Lucie Inlet	3.58	1.73	−1.52	−0.40	2.25	−0.52

TABLE 5.—Mean number of living individuals at Indian River localities

SPECIES	HAULOVER	BANANA	SEBASTIAN	JOHN'S ISLAND	VERO BEACH	LINKPORT	JIM'S FLAT	BUOY 195	HERMAN'S BAY	JENSEN BEACH	ST. LUCIE TRANSECT	ST. LUCIE INLET	GRAND MEAN
AMMONIA BECCARII..................	37.75	45.67	68.25	87.67	90.30	69.17	78.00	177.40	75.90	31.60	134.00	74.75	80.87
BOLIVINA STRIATULA................	7.25	0.00	8.50	23.56	12.40	12.67	9.50	50.50	87.00	16.20	31.90	23.25	23.56
QUINQUELOCULINA SEMINULA..........	46.50	3.00	8.00	8.67	10.10	2.83	44.25	5.80	12.40	8.90	38.70	9.75	16.57
QUINQUELOCULINA IMPRESSA..........	17.75	76.33	7.25	19.22	14.80	0.83	27.50	1.10	7.10	5.60	4.70	2.75	15.41
BULIMINELLA ELEGANTISSIMA.........	1.00	0.00	3.50	4.89	2.10	4.50	13.00	30.30	21.70	5.00	24.50	70.25	15.06
ELPHIDIUM MEXICANUM...............	7.75	1.67	33.25	2.11	10.60	1.17	10.25	1.50	0.50	2.40	16.40	15.75	8.61
ELPHIDIUM EXCAVATUM...............	4.75	10.00	9.75	15.89	2.80	5.67	2.25	8.50	0.90	0.60	2.10	17.50	6.73
NONIONELLA AURICULA...............	0.25	0.00	3.00	0.44	0.10	2.33	6.50	6.10	16.40	4.00	11.40	4.25	4.56
ELPHIDIUM GUNTERI.................	0.25	4.33	0.75	13.11	22.00	7.83	0.00	1.20	1.70	1.30	0.10	0.25	4.40
CYCLOGYRA PLANORBIS...............	7.25	0.00	1.75	0.00	0.00	0.00	22.00	0.00	0.20	0.00	0.60	7.50	3.28
ROSALINA FLORIDANA................	0.00	0.00	0.00	0.11	6.00	5.50	0.00	1.60	0.80	1.20	2.20	1.75	1.60
ROSALINA GLOBULARIS...............	0.50	0.00	0.50	1.00	2.00	1.00	1.25	2.10	0.70	1.50	4.50	3.25	1.53
GAUDRYINA EXILIS..................	0.00	0.00	0.75	0.22	0.50	0.00	1.25	8.30	0.20	1.60	3.90	0.50	1.44
ELPHIDIUM KUGLERI.................	1.50	0.67	0.50	0.44	2.30	0.00	3.50	3.00	1.10	0.00	0.60	3.00	1.38
AMMOBACULITES EXILIS..............	0.00	1.33	1.75	0.44	0.60	0.00	5.50	2.90	0.00	0.80	0.20	0.25	1.15
MEAN TOTAL OF ABUNDANT SPECIES....	132.50	143.00	147.50	177.78	176.60	113.50	224.75	300.30	226.60	80.70	275.80	234.75	
MEAN TOTAL OF ALL SPECIES.........	139.50	149.33	149.50	182.22	186.00	118.33	254.50	316.10	249.90	93.90	292.30	248.50	
...............H..................	1.929	1.361	1.771	1.783	1.953	1.646	2.283	1.712	2.011	2.451	1.997	2.145	
...............E..................	0.328	0.325	0.326	0.213	0.214	0.216	0.327	0.105	0.144	0.237	0.142	0.231	
NUMBER OF SPECIES.................	21	12	18	28	33	24	30	53	52	49	52	37	
NUMBER OF OBSERVATIONS............	4	3	4	9	10	6	4	10	10	10	10	4	
TOTAL INDIVIDUALS.................	558	448	598	1640	1860	710	1018	3161	2499	939	2923	994	

TABLE 6.—Standardized canonical discriminant function coefficients

Species	*Function 1*	*Function 2*
Ammonia beccarii	−0.02	−0.38
Bolivina striatula	0.63	−0.64
Quinqueloculina seminula	0.37	0.13
Quinqueloculina impressa	−0.09	−0.58
Buliminella elegantissima	0.13	0.78
Elphidium mexicanum	0.47	−0.17
Elphidium excavatum	−0.12	−0.45
Nonionella auricula	−0.58	0.16
Elphidium gunteri	−0.75	−0.11
Cyclogyra planorbis	0.85	0.20
Rosalina floridana	−0.51	0.37
Rosalina globularis	−0.10	0.39
Gaudryina exilis	−0.87	0.57
Elphidium kugleri	0.12	0.12
Ammobaculites exilis	0.28	−0.16

(Figure 16), and *Elphidium mexicanum* (Figure 11). Some of these species have higher than average densities at Haulover and the inlets, whereas others have lower than average densities. In particular, the species *C. planorbis* and *E. mexicanum* have higher than average densities at Haulover and the inlets.

We recall that the second canonical variate contrasts northern and southern areas. The canonical discriminate function coefficients (Table 6) indicate that, in order of importance, the most important species are *Buliminella elegantissima* (Figure 6), *Bolivina striatula*, *Quinqueloculina impressa* (Figure 14), and *Gaudryina exilis* (Figure 12). *Quinqueloculina impressa* increases in density northward, whereas the other species increase southward.

Tables 5 and 6 show that the canonical variate

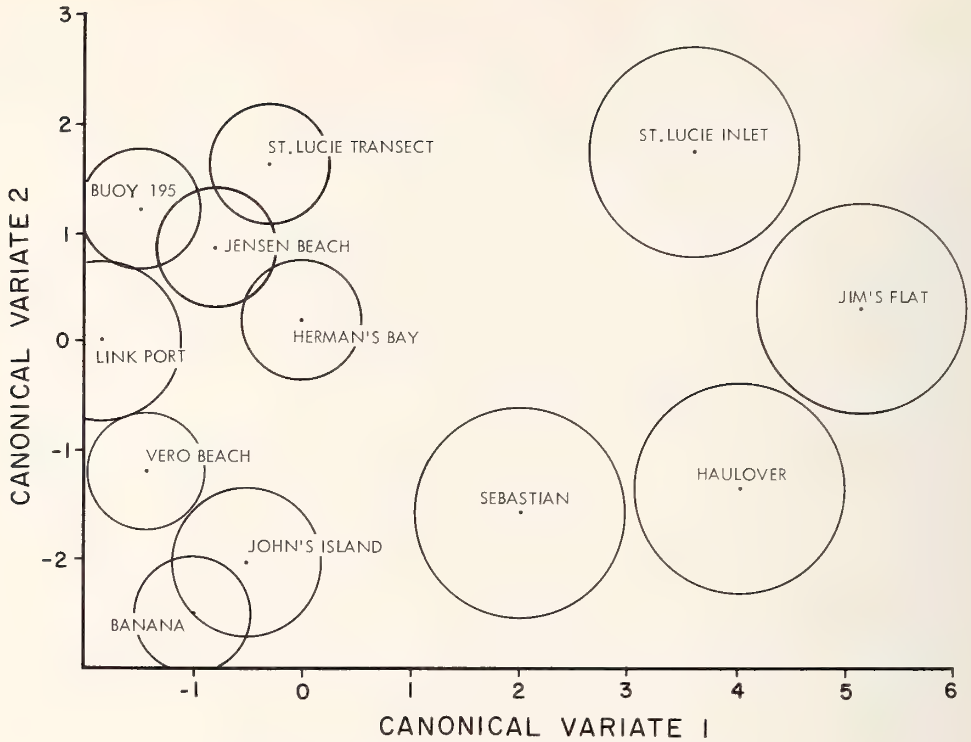


FIGURE 2.—Plot of mean canonical variates 1 and 2.

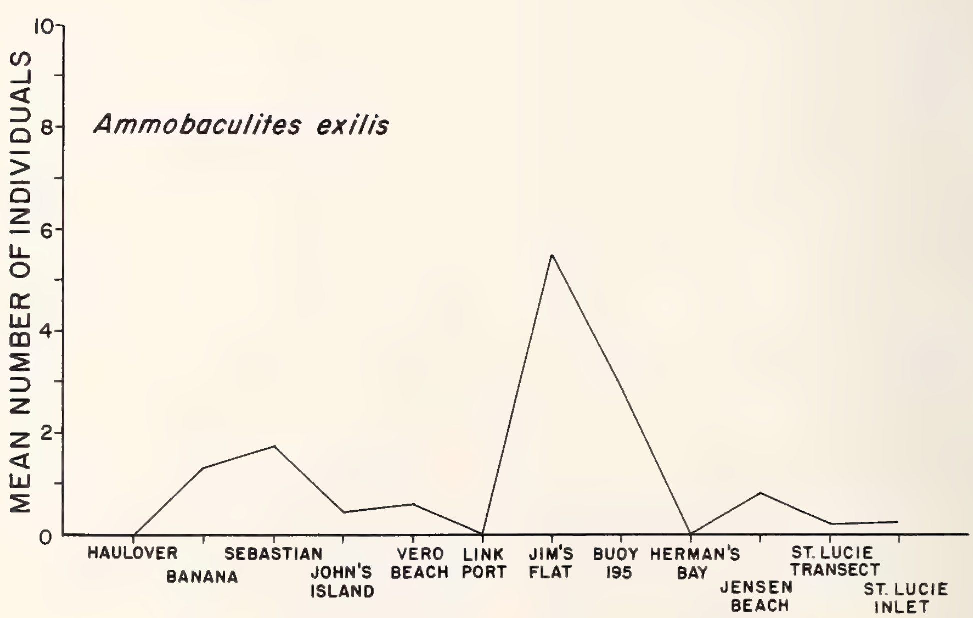


FIGURE 3.—Mean densities of *Ammobaculites exilis* at Indian River sampling sites.

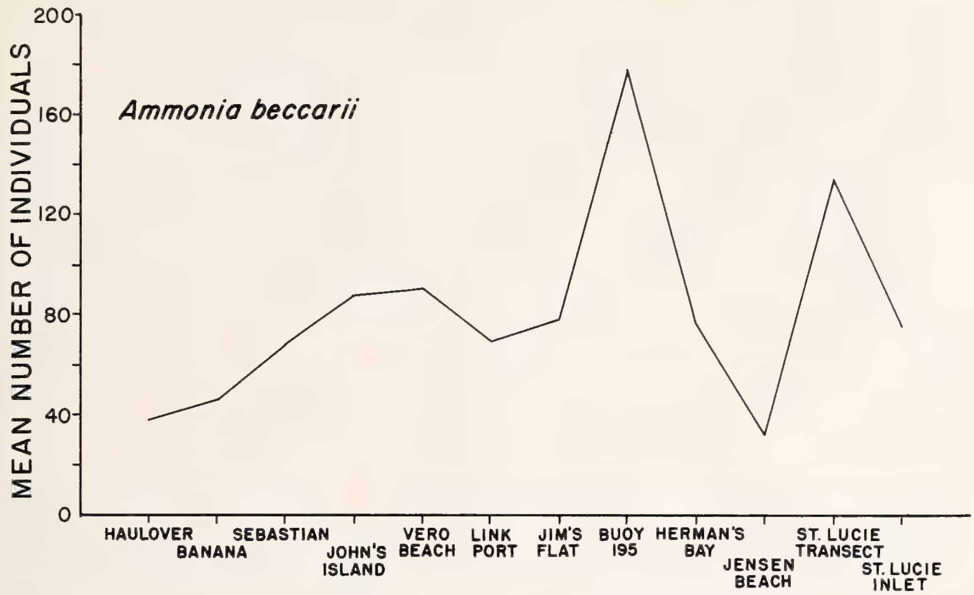


FIGURE 4.—Mean densities of *Ammonia beccarii* at Indian River sampling sites.

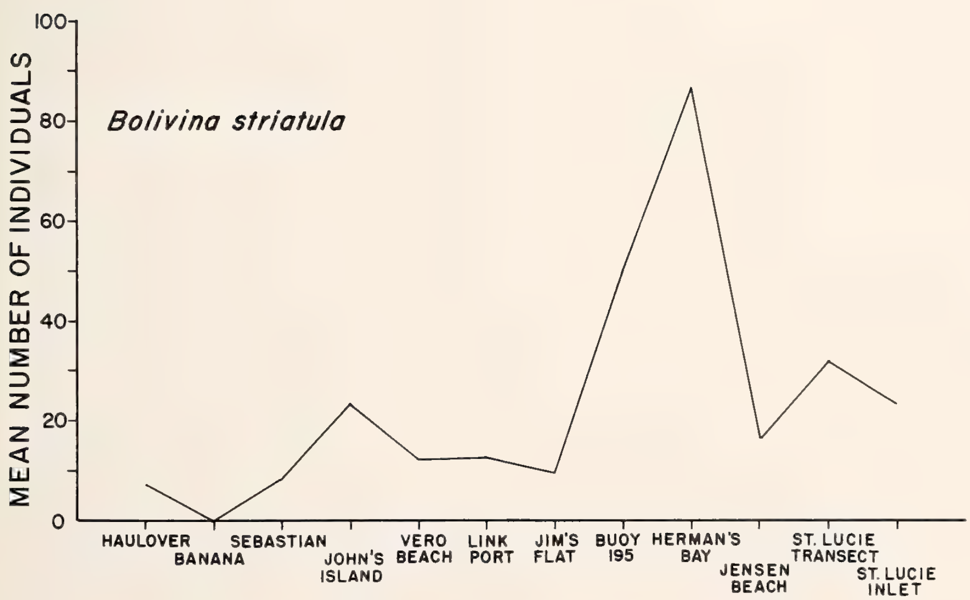


FIGURE 5.—Mean densities of *Bolivina striatula* at Indian River sampling sites.

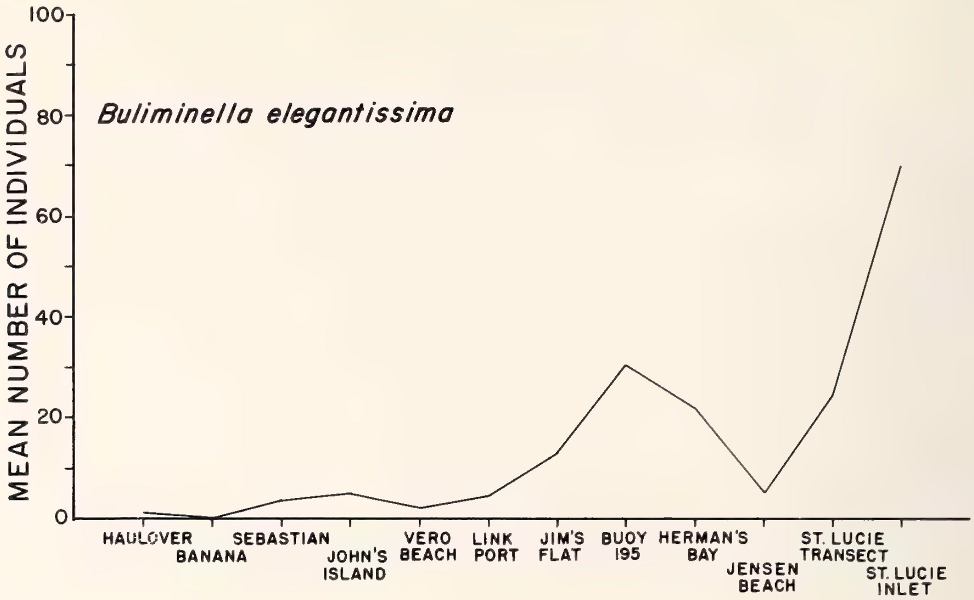


FIGURE 6.—Mean densities of *Buliminella elegantissima* at Indian River sampling sites.

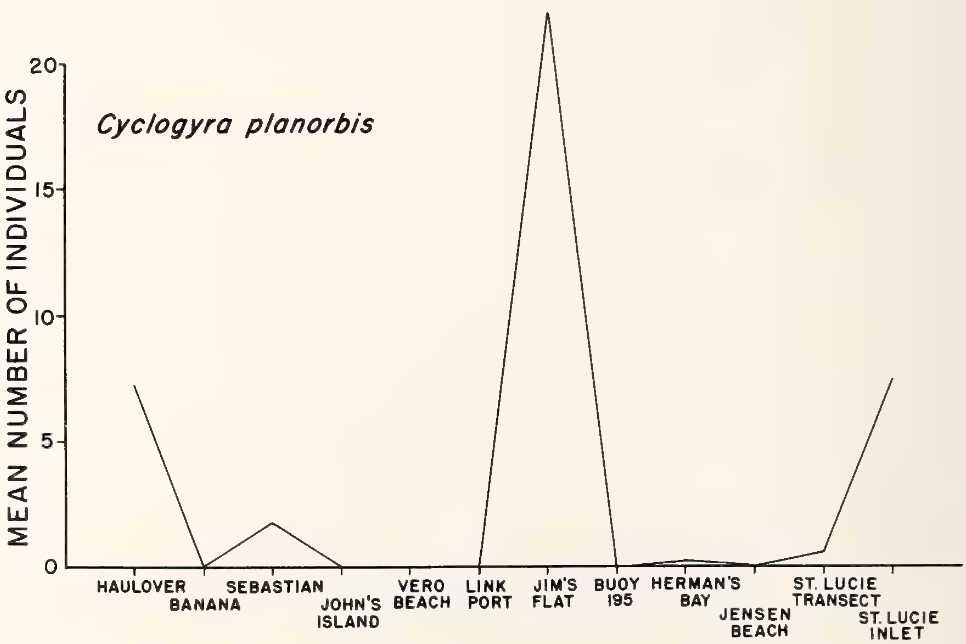


FIGURE 7.—Mean densities of *Cyclogyra planorbis* at Indian River sampling sites.

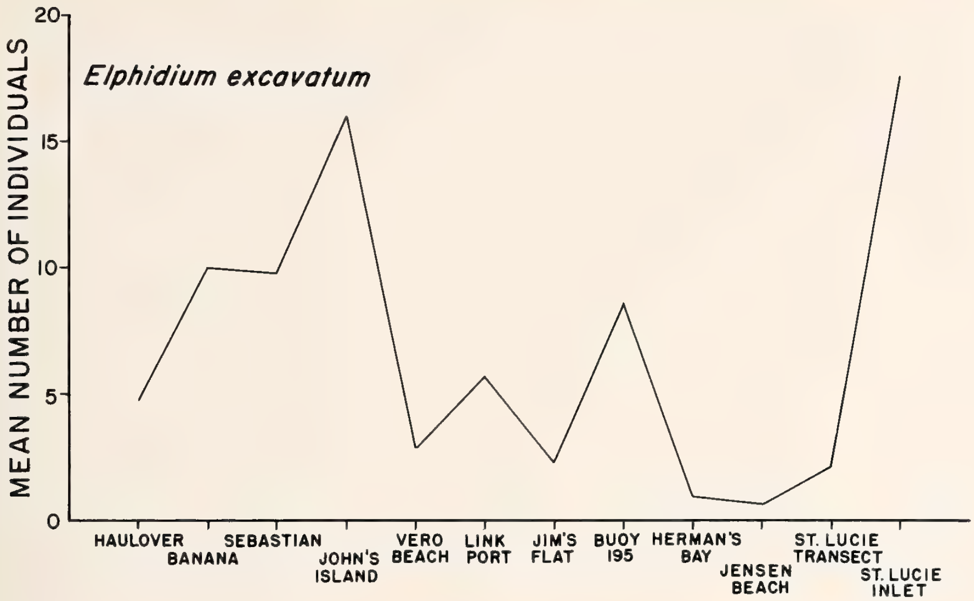


FIGURE 8.—Mean densities of *Elphidium excavatum* at Indian River sampling sites.

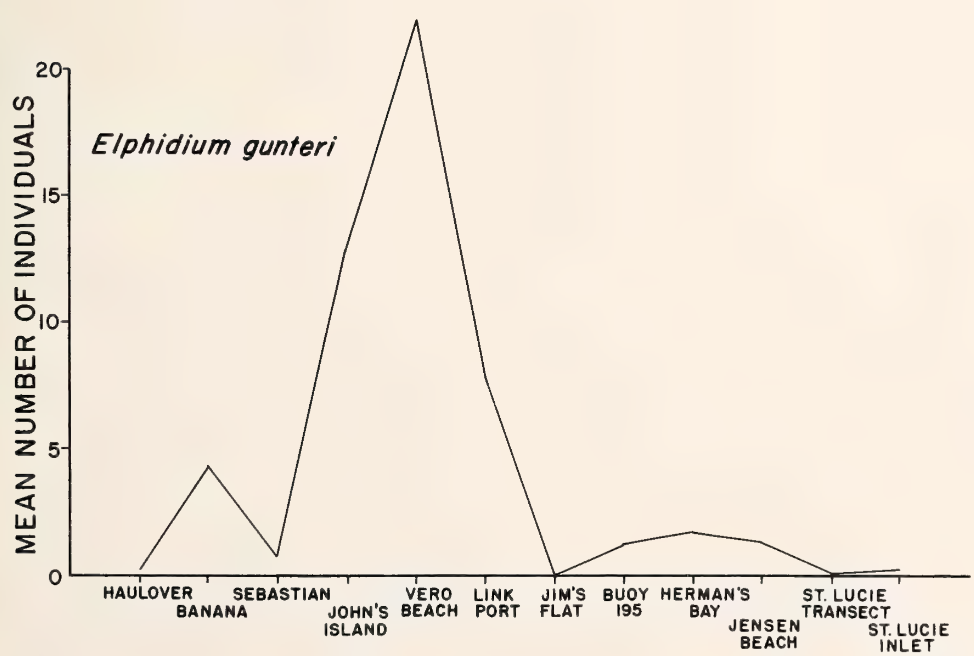


FIGURE 9.—Mean densities of *Elphidium gunteri* at Indian River sampling sites.

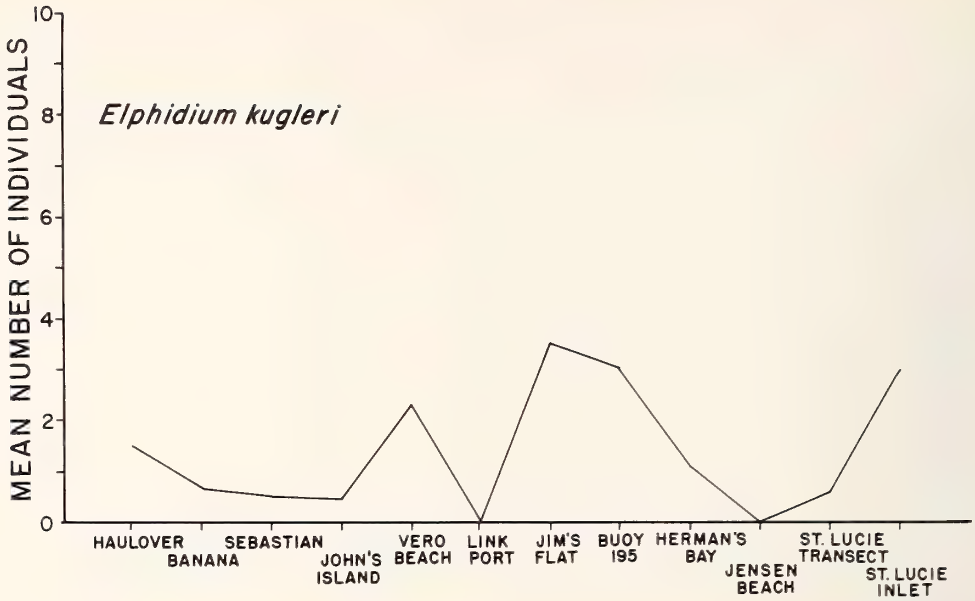


FIGURE 10.—Mean densities of *Elphidium kugleri* at Indian River sampling sites.

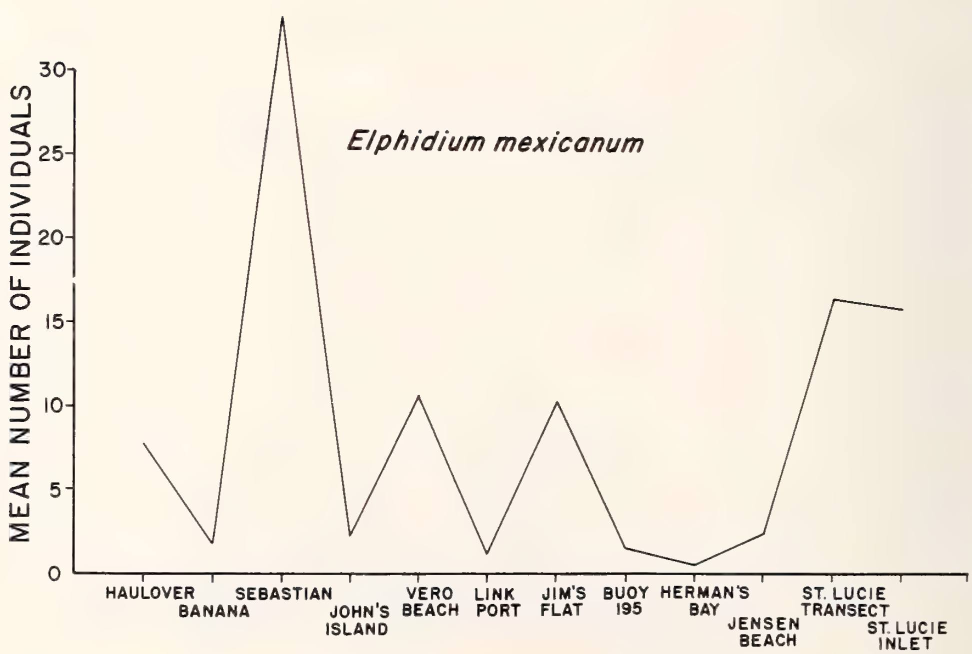


FIGURE 11.—Mean densities of *Elphidium mexicanum* at Indian River sampling sites.

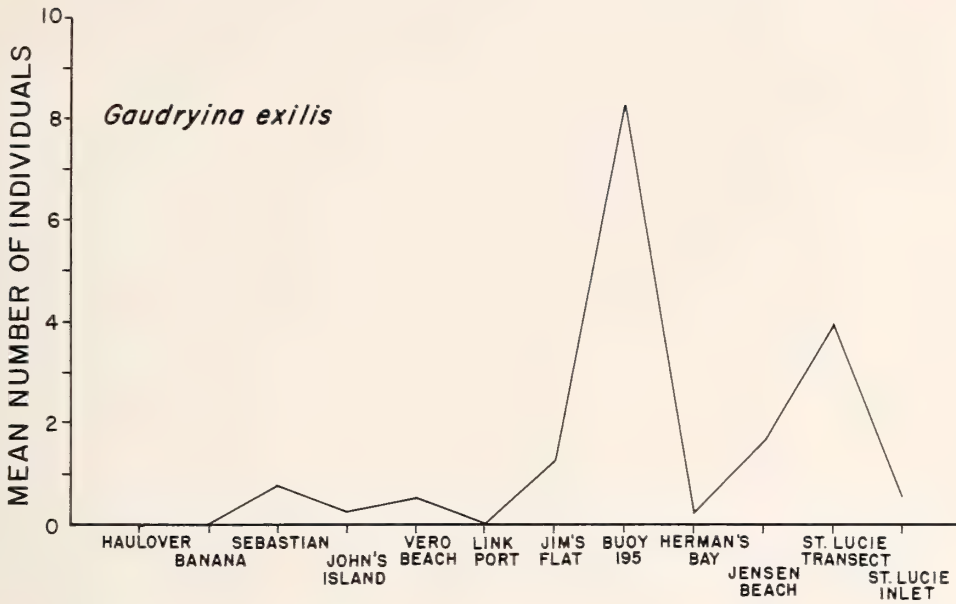


FIGURE 12.—Mean densities of *Gaudryina exilis* at Indian River sampling sites.

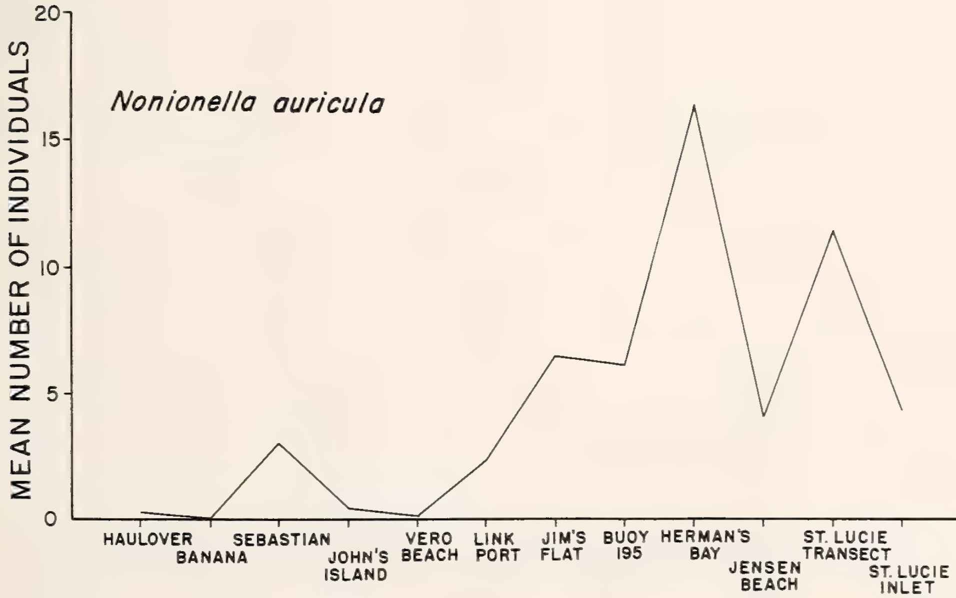


FIGURE 13.—Mean densities of *Nonionella auricula* at Indian River sampling sites.

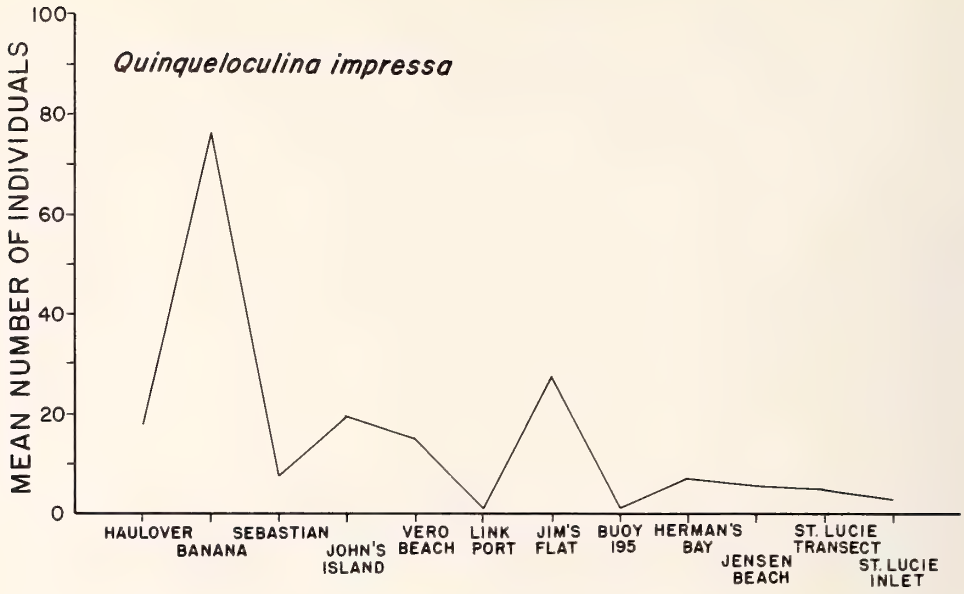


FIGURE 14.—Mean densities of *Quinqueloculina impressa* at Indian River sampling sites.

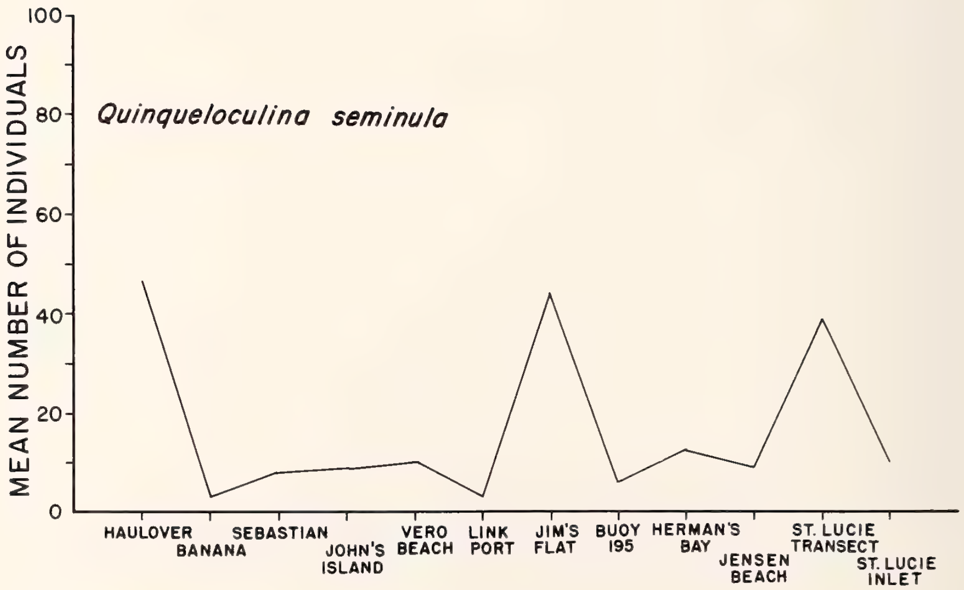


FIGURE 15.—Mean densities of *Quinqueloculina seminula* at Indian River sampling sites.

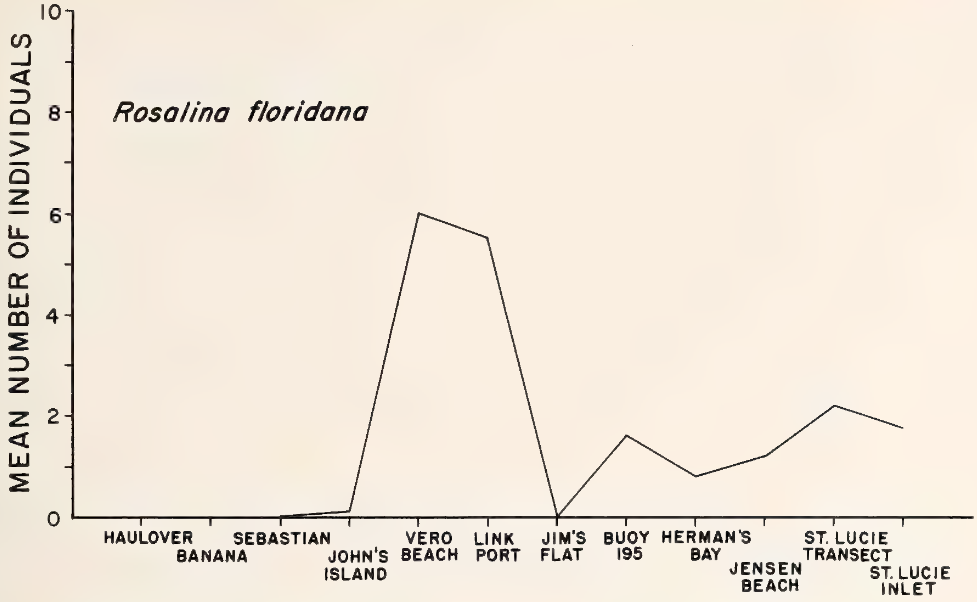


FIGURE 16.—Mean densities of *Rosalina floridana* at Indian River sampling sites.

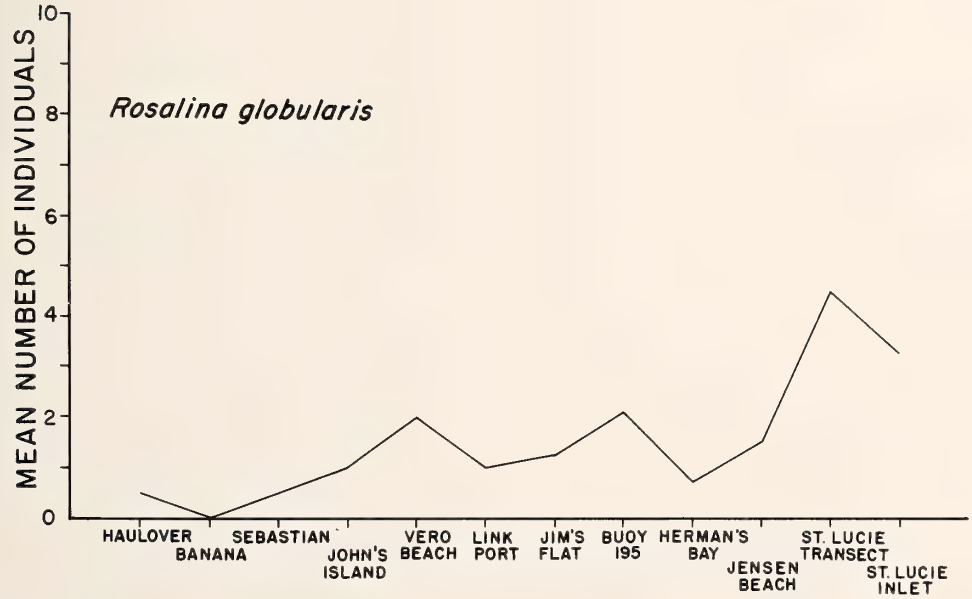


FIGURE 17.—Mean densities of *Rosalina globularis* at Indian River sampling sites.

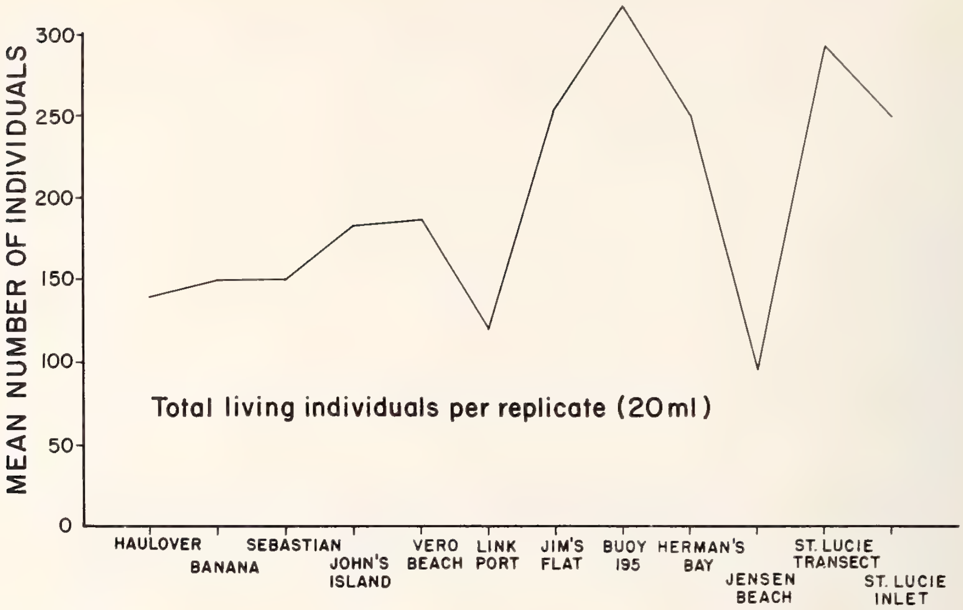


FIGURE 18.—Mean densities of total living population at Indian River sampling sites.

analysis used a combination of some of the more abundant species, such as *Bolivina striatula* and *Buliminella elegantissima*, as well as some of the less abundant ones, such as *Gaudryina exilis* and *Elphidium gunteri*, for discriminating the various areas. The most abundant species, *Ammonia beccarii*, is of little importance in the analysis as it occurs abundantly everywhere (Figure 4).

The third, fourth, fifth and sixth canonical variates are statistically significant (Table 3) and together account for about 36% of the total variance. They do not, however, provide any particularly interpretable contrasts. Perhaps the only information that can be gleaned from them is that the Indian River is extremely variable, a fact confirmed by the canonical analysis attempted on the individual stations.

We will briefly review where each species has its maximum or peak density relative to other areas. For standardization, we define a peak density as one exceeding twice the average density of the species over the entire area.

At the Haulover station, *Cyclogyra planorbis* and *Quinqueloculina seminula* (Figure 15) exhibit peak densities. The Banana station has a maximum density achieved by *Q. impressa*, five times its average density. At Sebastian Inlet, *Elphidium mexicanum* attains its maximum density, four times greater than average. The John's Island transect has peak densities for *E. excavatum* (Figure 8) and *E. gunteri*. At the Vero Beach transect, *E. gunteri* and *Rosalina floridana* reach their maximum densities of four to five times their average densities. The Link Port transect also has a peak density for *R. floridana*. Jim's Flat has maximum densities for *Ammobaculites exilis* (Figure 3), *C. planorbis*, and *E. kugleri* (Figure 10). *Quinqueloculina seminula* is also abundant at Jim's Flat. The Buoy 195 transect has a maximum density for *Ammonia beccarii* (Figure 4), by far the most abundant species in the Indian River (Table 5). *Ammobaculites exilis*, *Bolivina striatula*, *Buliminella elegantissima*, *E. kugleri*, and *G. exilis* also have high densities at the Buoy 195 transect. The Herman's Bay transect has maximum densities for *Bolivina striatula*, the second most abundant species in the Indian River, and *Nonionella auricula*. At Jensen Beach all species have densities below their average, except for *G. exilis*, which maintains its average density. The St. Lucie transect has maximum densities for *G. exilis* and *R. globularis* (Figure 17). *Nonionella auricula* and *Q. seminula* are also abundant. The St. Lucie Inlet has maximum densities for *Buliminella elegantissima* and *E. excavatum*. The species *C. plan-*

orbis, *E. kugleri*, and *R. globularis* also have high densities at the St. Lucie Inlet.

This brief review indicates that various areas in the Indian River are characterized or discriminated by different abundances of the 15 most common species. The trend of increasing density southward is shown clearly in Figure 18, which plots the mean number of total living individuals per 20-ml replicate. With the exception of the Jensen Beach transect, the density of foraminifera clearly increases in a southerly direction.

Species Diversity

The number of species found at the 12 areas is plotted on Figure 19 and listed in Table 5. In general there is an increase in the number of species encountered to the south. The greatest number of species was found at Buoy 195, Herman's Bay, Jensen Beach, and St. Lucie transect. In the northern half of the Indian River, Vero Beach had the greatest number of species encountered.

Table 5 lists the values for the information function H at the 12 areas, and Figure 20 is a plot of them. The same trend of increasing species diversity to the south is evident. Because the information function gives less weight to rare species, the amplitude of the curve is diminished. Some other differences are also notable. Maxima for the information function occur at Jim's Flat and Jensen Beach, and an increase rather than a decrease occurs from St. Lucie transect to St. Lucie Inlet. This happens because the value of information function depends not only on the number of species but also upon their equitability (Gibson and Buzas, 1973).

A measure of species equitability, E (Buzas and Gibson, 1969), is listed in Table 5 and plotted on Figure 21. At Haulover, Banana, and Sebastian, equitability is nearly constant, and the information function's curve closely resembles the species number plot. At John's Island, Vero Beach, and Link Port, the equitability values are again constant but at a lower level, and the plot of the information function still resembles the species number plot. The Jim's Flat station has a rise in species equitability, whereas Buoy 195 has a decrease. The information function mimics this pattern and shows a higher value at Jim's Flat than at Buoy 195, the opposite of the species number plot. The same situation occurs at the remaining southern stations so that the information function plot closely resembles that of species equitability. If the criterion for "species diversity" is the information function, then maxima occur at Jim's Flat and Jensen Beach, areas with high equitabilities and number of species. If the criterion for "species diversity" is the number of species, then Buoy 195, Herman's Bay, Jensen Beach, and St. Lucie transect would be chosen. In any case, a trend of increasing species diversity toward the south is observed.

Because the number of species is correlated with the number of individuals (Buzas et al., 1977), it is no surprise that the southern area has a higher number of species than the northern area. Figure 22 is a semilog plot of the number of individuals found in each area against the number of species. The areas with the greatest number of species, Herman's Bay, St. Lucie transect, and Buoy 195, are also the areas with the greatest numbers of individuals. The Jensen Beach transect appears as an outlier in Figure 22. Although 10 replicates were collected in this transect, only 939 individuals were found, making Jensen Beach the area with the lowest mean density in the entire Indian River (Table 5). Nevertheless, 49 species were identified at Jensen Beach, and because the more abundant species occur there with low densities (Table 5), the equitability is higher than at adjacent stations. Consequently the information function reaches its maximum value at this transect.

We have not had an opportunity to investigate whether or not this anomalous pattern of low number of individuals and high number of species at Jensen Beach is due to some unique spatial pattern found only at that locality.

Distribution of Rare Species

The 15 most abundant species comprise 95% of the total living population for all areas except

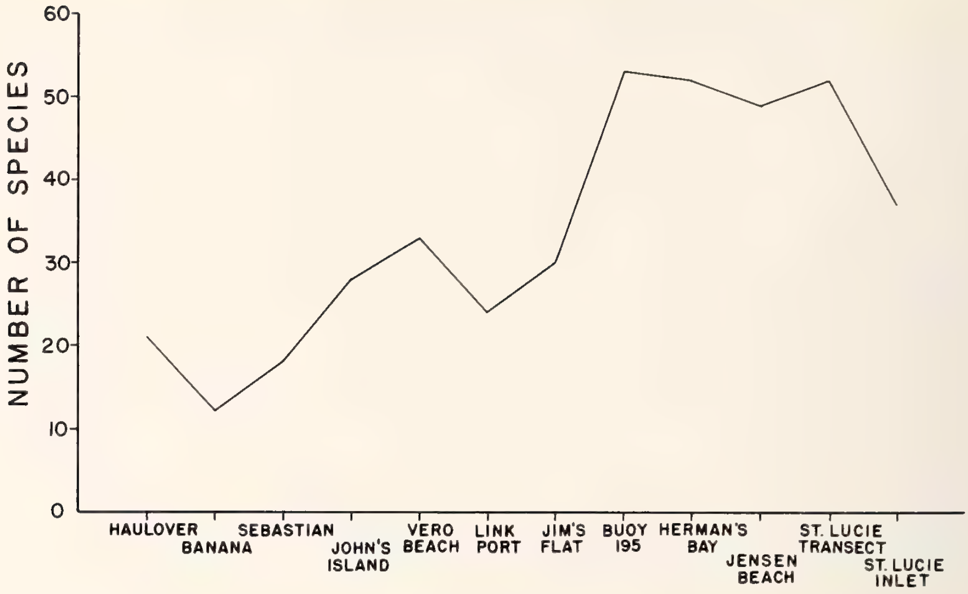


FIGURE 19.—Number of species recorded at Indian River sampling sites.

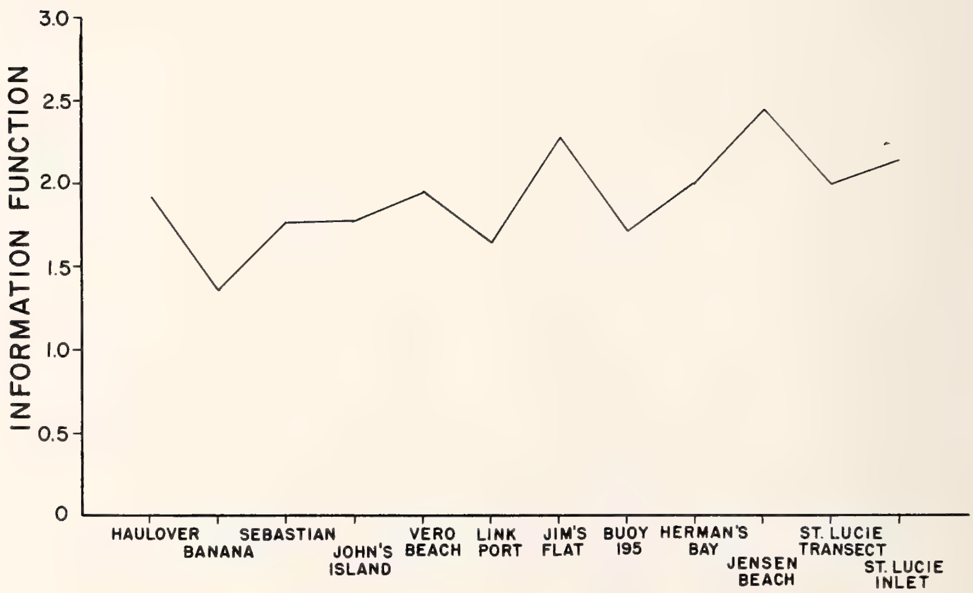


FIGURE 20.—Values of information function at Indian River sampling sites.

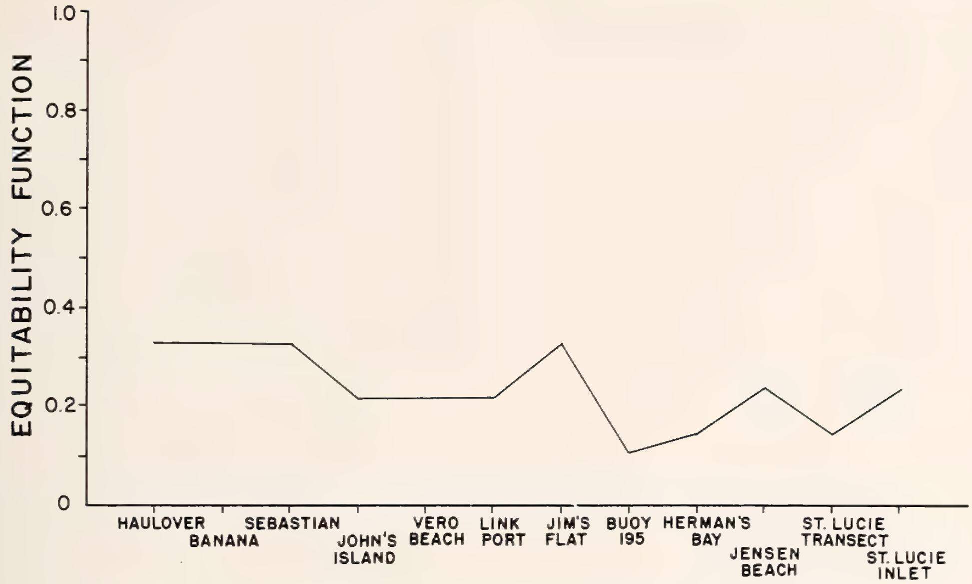


FIGURE 21.—Values of equitability function at Indian River sampling sites.

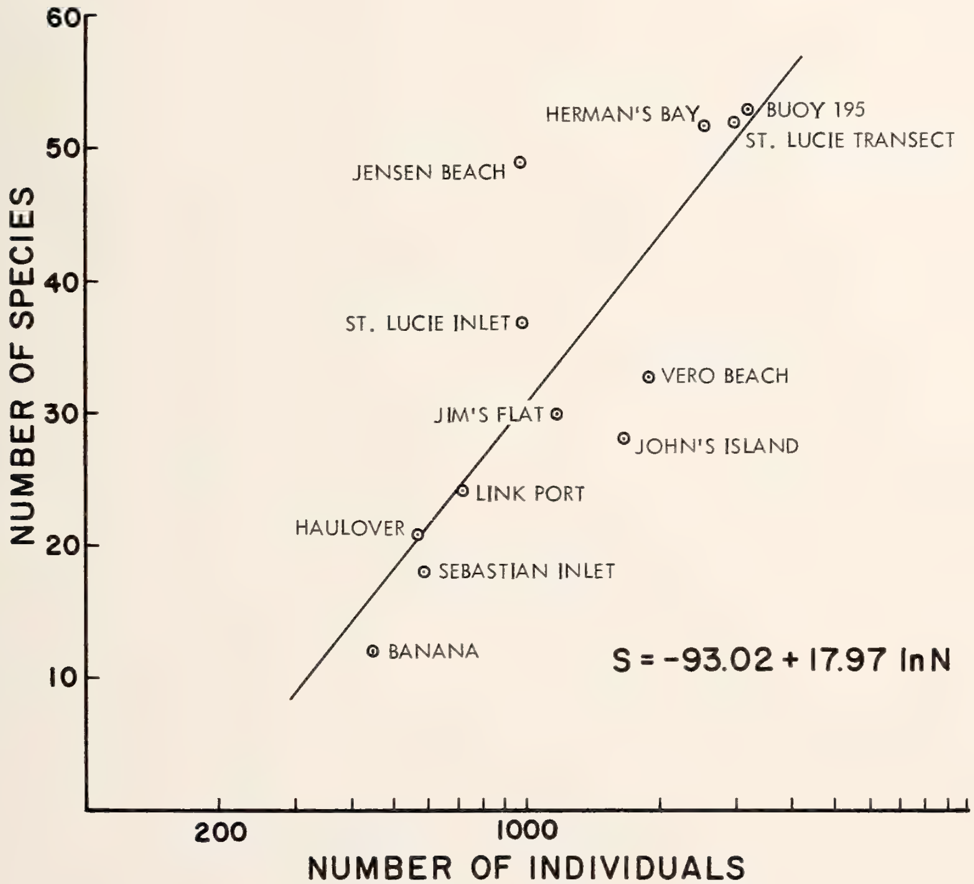


FIGURE 22.—Semilog plot of individuals vs. species in the Indian River.

Jim's Flat, Herman's Bay, and Jensen Beach (Table 5). At Jim's Flat the addition of 78 *Ishamella apertura* specimens brings the percentage from 88 to 96. *Ishamella apertura* could have been included with the most abundant species, as its grand total (79) is comparable to that of *Ammobaculites exilis* (83). Because this species is a very unusual foraminifer (see "Systematic Catalog"), and all specimens except one occur at Jim's Flat, we decided to exclude it from the analysis of the abundant species.

At Herman's Bay four rare species must be included to attain 95% of the total living population. These are *Ammobaculites* cf. *exilis* (53), *Hopkinsina pacifica* (22), *Quinqueloculina poeyana* (16), and *Bolivina* sp. B (13). The addition of *A.* cf. *exilis* alone brings the total to 95%, and it is possible that this species is merely a large grained form of *A. exilis* sensu stricto, which was included among the 15 most abundant species.

As pointed out earlier, Jensen Beach is very unusual because the total living population is low, and yet a large number of species was recorded there. At Jensen Beach eight species must be added to bring the total to 95%. These are: *Hopkinsina pacifica* (40), *Quinqueloculina poeyana* (9), *Elphidium advenum* (8), *Rosalina concinna* (8), *Fursenkoina fusiformis* (6), *Bolivina* sp. B (5), *Nonionella opima* (5), and *Quinqueloculina* cf. *akneriana* (5). This is the only area where more than 20 species are required to obtain 95% of the total living population.

The great disparity in densities among areas, the positive correlation between numbers of species and numbers of individuals, and the fact that 15 species almost always make up 95% of the total living population suggest that the use of rare species to discern meaningful spatial patterns is extremely hazardous. Because the probability of encountering a rare species is low, it is difficult to tell whether a species was not found because of chance or because it really wasn't there. On the other hand, the relatively large number (78) of *Ishamella apertura* found at Jim's Flat while only one specimen was found elsewhere does suggest that this species may have a very restricted distribution. A similar, but more tenuous, pattern may exist for *Hopkinsina pacifica*, *Quinqueloculina poeyana*, and *Bolivina* sp. B. These species were found at the adjacent Herman's Bay and Jensen Beach stations and were members of those species that make up 95% of the total living population.

Finally, two species occur at St. Lucie Inlet and St. Lucie transect and nowhere else in the Indian River. *Peneroplis pertusus* and *Sorites marginalis* are well-known tropical species. They occur abundantly in Florida Bay (Bock, 1971) and are probably at the northernmost limits of their ranges.

Discussion

Ideally, studies concerned with the distribution of organisms would sample all areas simultaneously over a long period to average out seasonal fluctuations in density. Unfortunately, this is rarely feasible due to economic and time constraints. In the present study, samples were taken in February, March, April, June, September, and December (Table 2). Data from Link Port taken over a four-year period (Buzas, 1978; 1982; unpublished) indicate a substantial variation in density from month to month. In general the winter months (December, February, and March) have low densities, June a moderate density, and April a high density. If seasonality, or time, rather than location were responsible for the density pattern observed, we would expect moderate densities at Haulover, Banana, Sebastian, Jim's Flat, and St. Lucie Inlet (all sampled in June). We would expect low densities at John's Island, Link Port, Buoy 195, Herman's Bay, and St. Lucie transect (all sampled in winter). Finally, we would expect a high density at Jensen Beach (sampled in April). Figure 18 clearly shows this is not the case. Instead, there is an overall increase in density southward, with the exception of Jensen Beach, which has the lowest density of anywhere! Therefore, we believe that the observed density pattern is a consequence of the area sampled rather than time of sampling.

When studying the distribution of foraminifera, researchers usually divide the study area into faunal zones or biofacies (Boltovskoy and Wright, 1976). The biofacies are defined either on the

basis of examination of the data or by the use of some numerical or statistical technique (Buzas, 1979). Examination of data usually shows that boundaries between biofacies are rarely discrete. However, the use of some numerical techniques, such as cluster analysis, forces samples into one group or another, and the amount of overlap may not be apparent. The results of the canonical variate analysis performed on the 15 most abundant species in the Indian River (Figure 2) shows that the inlets and Haulover are distinct from other areas. They do not, however, form a homogeneous group themselves. Each is distinct and would have to be assigned its own biofacies. The second canonical axis shows a north-south trend or arrangement of areas. St. Lucie transect is clearly different from Banana or John's Island, but the confidence circles from area to area overlap. At no point is there an indication of a simple break dividing, for example, the area into north and south biofacies. Consequently, we have decided not to designate any biofacies but to allow Figure 2 to stand as a representation of the foraminiferal distribution in the Indian River.

Young et al. (1976) reported an increase in density of decapods southward in the Indian River. In the adjacent ocean, Gore et al. (1978) found the same trend for the decapods inhabiting the sabellariid worm reefs that parallel the barrier island. On the other hand the macrobenthos, mostly polychaetes, exhibit a trend of decreasing density southward (Young et al., 1976; Young and Young, 1977). Amphipods inhabiting seagrass also have lower densities in southern areas as well as near inlets (Nelson et al., 1982). The decrease in density of macrobenthos and amphipods was attributed to predation by decapods on the former (Young et al., 1976; Young and Young, 1977) and by decapods and fish on the latter (Nelson et al., 1982).

Predation of foraminifera is common (Lipps and Valentine, 1970), and experiments indicate that foraminiferal densities in the Indian River are regulated by predation (Buzas, 1978; 1982). Buzas and Carle (1979) found foraminifera in the guts of deposit feeders, among them polychaetes and decapods. Unfortunately we do not know whether one group is more important in regulating foraminiferal density than the other. Consequently we cannot speculate with confidence as to whether or not the increase in foraminiferal densities southward is due to a change in predation pressure. The increase in density does correlate positively with increasing density of decapods and negatively with the densities of polychaetes and amphipods.

Young et al. (1976), Young and Young (1977), and Nelson et al. (1982) have pointed out a gradient of decreasing environmental variability toward the southern end of the Indian River. This decreasing gradient is positively correlated with the increase in foraminiferal density to the south. A similar pattern of higher foraminiferal density in an area of less environmental variability was reported by Buzas et al. (1977) in Jamaica, West Indies.

Hydrographically, the inlets and Haulover differ from other areas because they represent extremes of tidal influence. The inlets experience strong, diurnal tidal changes, whereas Haulover, in the "blind" end of the River, experiences almost no tidal influence at all. Each of these areas is discriminated by changes in the densities of the most abundant foraminiferal species in the Indian River. While species diversity generally increases southward, we observed no increase in species diversity at the three inlets. This contrasts markedly with Gilmore (1977), who found the highest number of fish species at inlets, and Mook (1980), who found an increased diversity of fouling organisms at Fort Pierce Inlet as compared to Vero Beach.

No studies of foraminifera have been made in estuaries near the Indian River. To the north in Pamlico Sound, North Carolina, Grossman (1967) defined several biofacies. Some biofacies are characterized by species such as *Elphidium excavatum* and *E. gunteri*, which also occur in the Indian River. In general, however, the Pamlico Sound fauna is very different from the Indian River fauna.

Farther south, foraminifera have been studied in Florida Bay and adjacent waters by Stubbs (1940), Bock et al. (1971), and Rose and Lidz

(1977). Bock (1971) and Rose and Lidz (1977) have defined biofacies containing abundant *Ammonia beccarii*, the dominant species in the Indian River. The foraminiferal fauna of these southern waters, however, does not closely resemble the fauna from the Indian River. The sediments to the south are mainly carbonates (Milliman et al., 1972), unlike the quartz sands of the Indian River. This carbonate sedimentary regime marks the northernmost extension of the Bahamian or Caribbean faunal province (Buzas and Culver, 1980), thus explaining why the foraminiferal species are so different between central and southern Florida.

Systematic Catalog

The following catalog uses the general systematic structure of the *Treatise of Paleontology* (Loeblich and Tappan, 1964), even though we believe the overall taxonomic philosophy of the *Treatise* is too rigid. For example, we have assigned species with both optically radial and granular walls to the genus *Elphidium*, although strict adherence to the *Treatise* would have placed them in different superfamilies. We believe, however, the systematic arrangement used here is more useful than an alphabetical scheme.

Where possible, our synonymies are based on direct inspection of the types cited. In a few cases the only specimens accessible were from Pacific collections or were topotypes.

Illustration of foraminifera is a continuing source of difficulty for researchers. Although it has become fairly easy to take high quality scanning electron micrographs, they do not convey the transparent qualities of foraminiferal tests, a severe drawback, as most work is done with optical microscopes. Furthermore, the gold coating necessary for scanning electron microscopy makes the specimen opaque and very difficult to use, subsequently, under a binocular microscope. The alternative, a good drawing by a scientific illustrator, does not harm the specimen and produces a view of the specimen as it appears under an optical microscope. For anything more than a small number of views, however, the time and expense are rarely justified.

In this study we have attempted to use scanning electron micrographs of very thinly coated specimens. The gold coating was 50 angstroms, about one-quarter of the thickness normally used. This coating is virtually transparent, and the specimens are still quite useful for optical work. The electron micrographs, however, tend to have charged areas and strange scan lines due to the inadequate conductivity of the thin coating. By using very low accelerating voltages (less than 5 KV), we were able to hold these bad effects to a minimum. In spite of this, a few of the figures have some visibly charged areas. We feel, however, that the preservation of the optical characters of the specimens warrants the defects in the figures.

Specimens deposited in the National Museum of Natural History, Smithsonian Institution, are listed under the abbreviation "USNM" (for the collection numbers of the former United States National Museum). Representatives of most species are deposited in the Indian River Coastal Zone Museum, Fort Pierce, Florida.

HIERARCHY.—From order through genus:

Order FORAMINIFERIDA Eichwald, 1830
Suborder ALLOGROMIINA Loeblich and Tappan, 1961
Superfamily LAGYNACEA Schultze, 1854
Family ALLOGROMIIDAE Rhumbler, 1904
Genus *Allogromia* Rhumbler, 1904
Suborder TEXTULARIINA Delage and Herouard, 1896
Superfamily LITUOLACEA de Blainville, 1825
Family HORMOSINIDAE Haeckel, 1894
Subfamily HORMOSININAE Haeckel, 1894
Genus *Reophax* Montfort, 1808
Family LITUOLIDAE de Blainville, 1825
Subfamily LITUOLINAE de Blainville, 1825
Genus *Ammobaculites* Cushman, 1910
Family TROCHAMMINIDAE Schwager, 1877
Subfamily TROCHAMMININAE Schwager, 1877
Genus *Trochamina* Parker and Jones, 1859
Family ATOXOPHRAGMIIDAE Schwager, 1877
Subfamily VERNEUILININAE Cushman, 1911
Genus *Gaudryina* d'Orbigny, 1839
Suborder MILIOLINA Delage and Herouard, 1896
Superfamily MILIOLACEA Ehrenberg, 1839
Family FISCHERINIDAE Millet, 1898
Subfamily CYCLOGYRINAE Loeblich and Tappan, 1961

Genus *Cyclogyra* Wood, 1842
Family Nubeculariidae Jones, 1875
Subfamily Ophthalmidiinae Weisner, 1920
Genus *Edentostomina* Collins, 1958
Genus *Weisnerella* Cushman, 1933
Subfamily Spiroloculininae Weisner, 1920
Genus *Spiroloculina* d'Orbigny, 1826
Family Miliolidae Ehrenberg, 1839
Subfamily Quinqueloculininae Cushman, 1917
Genus *Quinqueloculina* d'Orbigny, 1826
Genus *Massilina* Schlumberger, 1893
Genus *Pateoris* Loeblich and Tappan, 1953
Genus *Triloculina* d'Orbigny, 1826
Subfamily Miliolinellinae Vella, 1957
Genus *Miliolinella* Weisner, 1931
Genus *Biloculinella* Weisner, 1931
Genus *Scutuloris* Loeblich and Tappan, 1953
Subfamily Tubinellinae Rhumbler, 1906
Genus *Tubinella* Rhumbler, 1906
Genus *Articulina* d'Orbigny, 1826
Ishamella, new genus
Family Soritidae Ehrenberg, 1839
Subfamily Peneroplinae Schultze, 1854
Genus *Peneroplis* Montfort, 1808
Subfamily Soritinae Ehrenberg, 1839
Genus *Sorites* Ehrenberg, 1839
Suborder Rotaliina Delage and Herouard, 1896
Superfamily Nodosariacea Ehrenberg, 1838
Family Nodosariidae Ehrenberg, 1838
Subfamily Nodosariinae Ehrenberg, 1838
Genus *Lagena* Walker and Jacob
Family Glandulinidae Reuss, 1860
Subfamily Oolininae Loeblich and Tappan, 1961
Genus *Fissurina* Reuss, 1850
Superfamily Buliminacea Jones, 1875
Family Turrilinidae Cushman, 1927
Subfamily Turrilininae Cushman, 1927
Genus *Buliminella* Cushman, 1911
Family Bolivinitidae Cushman, 1927
Genus *Bolivina* d'Orbigny, 1839
Family Buliminidae Jones, 1875
Subfamily Bulimininae Jones, 1875
Genus *Bulimina* d'Orbigny, 1826
Subfamily Pavonininae Eimer and Fickert, 1899
Genus *Pavonina* d'Orbigny, 1826
Family Uvigerinidae Haeckel, 1894
Genus *Hopkinsina* Howe and Wallace, 1932
Genus *Trifarina* Cushman, 1923
Superfamily Discorbacea Ehrenberg, 1838
Family Discorbidae Ehrenberg, 1838
Subfamily Discorbinae Ehrenberg, 1838
Genus *Rosalina* d'Orbigny, 1826
Genus *Stetsonia* Parker, 1954
Family Glabratellidae Loeblich and Tappan, 1964
Genus *Glabratella* Dorreen, 1948
Genus *Glabratellina* Seiglie and Bermudez, 1965
Superfamily Spirillinacea Reuss, 1862
Family Spirillinidae Reuss, 1862
Subfamily Spirillininae Reuss, 1862
Genus *Mychostomina* Berthelin, 1881
Superfamily Rotaliacea Ehrenberg, 1839
Family Rotaliidae Ehrenberg, 1839
Subfamily Rotaliinae Ehrenberg, 1839
Genus *Ammonia* Brünnich, 1772
Family Elphidiidae Galloway, 1933
Subfamily Elphidiinae Galloway, 1933
Genus *Elphidium* Montfort, 1808
Genus *Haynesina* Banner and Culver, 1978
Superfamily Orbitoidacea Schwager, 1876
Family Eponididae Hofker, 1951
Genus *Eponides* de Montfort, 1808
Family Cibicididae Cushman, 1927
Subfamily Cibicidinae Cushman, 1927
Genus *Cibicides* de Montfort, 1808
Family Planorbulinidae Schwager, 1877
Genus *Planorbulina* d'Orbigny, 1826
Family Cymbaloporidae Cushman, 1928
Genus *Cymbaloporetta* Cushman, 1928
Superfamily Cassidulinacea d'Orbigny, 1839
Family Caucasinidae Bykova, 1959
Subfamily Fursenkoininae Loeblich and Tappan, 1961
Genus *Fursenkoina* Loeblich and Tappan, 1961
Genus *Sigmavirgulina* Loeblich and Tappan, 1957
Family Cassidulinidae d'Orbigny, 1839
Genus *Cassidulina* d'Orbigny, 1826
Family Nonionidae Schultze, 1854
Subfamily Nonioninae Schultze, 1854
Genus *Nonion* de Montfort, 1808
Genus *Nonionella* Cushman, 1926
Family Anomalinidae Cushman, 1927
Genus *Hanzawaia* Asano, 1944

Genus *Allogromia* Rhumbler, 1904

?*Allogromia* species

Since the technique used in preparing the samples included several acetone rinses and drying under heat lamps, there is a good possibility that most of the allogromids present were destroyed. Perhaps these specimens are not *Allogromia* at all and may merely be pieces of debris that were stained by the rose bengal.

Specimens scattered throughout the Indian River are thus referred. (Total: 12; range: 0–3.)

Genus *Reophax* Montfort, 1808

Reophax nana Rhumbler

PLATE 1: FIGURE 1

Reophax nana Rhumbler, 1913:471, 472, pl. 8: figs. 6–12.—Parker, 1952b:457, pl. 1: figs. 14, 15.—Parker, Phleger, and Peirson, 1953:13, pl. 1: fig. 11.—Todd and Bronniman, 1957:22, pl. 1: fig. 17.—Lankford, 1959:2099, pl. 1: fig. 2.—Buzas, 1965b:55, pl. 1: fig. 2.

A few specimens, mostly from the Fort Pierce and St. Lucie inlets, were referred to this category.

Figured hypotype: USNM 310285. (Total: 18; range: 0–7.)

Genus *Ammobaculites* Cushman, 1910

Ammobaculites exiguus Cushman and Bronniman

PLATE 1: FIGURES 2, 3

Ammobaculites exiguus Cushman and Bronniman, 1948b:38, 39, pl. 7: figs. 7, 8.—Parker, Phleger, and Peirson, 1953:5, pl. 1: fig. 16.—Bandy, 1956:192, pl. 30: fig. 2.—Todd and Bronniman, 1957:23, pl. 2: fig. 7.—Lankford, 1959:2097, pl. 1: fig. 9.

The specimens referred to this category are generally more slender than those referred to *Ammobaculities exilis* and have a much rounder cross section in the uniserial portion. For a further discussion see *A. exilis.*

All but one of the specimens are from the Buoy 195 transect.

Figured hypotype: USNM 310280. (Total: 6; range: 0–4.)

Ammobaculites exilis Cushman and Bronniman

PLATE 1: FIGURES 4, 5

Ammobaculites exilis Cushman and Bronniman, 1948b:39, pl. 7: fig. 9.—Bandy, 1956:192, pl. 30: fig. 3.—Buzas, Smith, and Beem, 1977:64, pl. 1: figs. 5, 6.

All specimens referred to this category are fine grained and match the holotype and paratypes well. The neck is generally compressed. Only a few of the specimens are uncoiling, and only a few have distinct sutures.

Although some authors have chosen to synonomize *Ammobaculites exilis* with *A. exiguus*, we feel that in the Indian River there are two distinct populations: one, *A. exilis*, is compressed and only slowly uncoiling into a uniserial section; the other, *A. exiguus*, is rather inflated and has a distinct break between the coiled early section of the test and the cylindrical uniserial later portion.

This species occurs throughout the Indian River and is most abundant near Fort Pierce Inlet (Jim's Flat of this study).

Figured hypotype: USNM 310281. (Total: 83; range: 0–23.)

Ammobaculites cf. *exilis* Cushman and Bronniman

PLATE 1: FIGURES 6, 7

Specimens thus referred are similar in shape to *Ammobaculites exilis* sensu stricto but have tests composed of much coarser grains. As we do not see a gradational series between the coarse- and fine-grained forms and do find both forms in the same replicate, we do not feel that the forms are conspecific. Unfortunately there are never more than three of each form in a replicate, and so it is possible that we never see a large enough sample to get a complete view of the population.

Ammobaculites cf. *exilis* is the only form of *Ammobaculites* found at Herman's Bay. Perhaps further investigation would reveal the sediment there to be composed of coarser-than-average grains.

Figured specimen: USNM 310282. (Total: 69; range: 0–20.)

Genus *Trochamina* Parker and Jones, 1859

Trochamina cf. *advena* Cushman

PLATE 1: FIGURES 8, 9

The specimens referred to this category have deeper sutures than do the types from the Dry Tortugas, designated by Cushman in 1922. They resemble *Trochamina* cf. *advena* of Phleger, Parker, and Peirson (1953). They also resemble the specimens designated *T. advena* by Phleger and Parker (1951) and Parker (1952a, 1954). They differ

enough from the primary types, and so we feel that synonymization cannot be made.

Most of the specimens were collected at Buoy 195.

Figured specimen: USNM 310286. (Total: 11; range: 0–4.)

Trochamina ochracea (Williamson)

PLATE 1: FIGURES 10, 11

Rotalina ochracea Williamson, 1858:55, pl. 4: fig. 112; pl. 5: fig. 113.
Trochamina ochracea (Williamson).—Cushman 1944:19, pl. 2: figs. 12, 13.—Parker, 1952a:408, 409, pl. 4: figs. 13, 14; 1952b:460, pl. 3: fig. 5.—Todd and Low, 1961:16, pl. 1: fig. 18.

Our specimens have the compressed concave-convex test and umbilical flaps characteristic of this normally deep-water species.

Most were found in the southern part of the Indian River.

Figured hypotype: USNM 310287. (Total: 25; range: 0–8.)

Trochamina species

Three small specimens are thus referred. Unfortunately, the single unbroken specimen was lost. This specimen had a high spire and clearly showed three chambers in the final whorl.

All specimens were collected at Buoy 195. (Total: 3; range: 0–3.)

Genus *Gaudryina* d'Orbigny, 1839

Gaudryina exilis Cushman and Bronniman

PLATE 1: FIGURES 12, 13

Gaudryina exilis Cushman and Bronniman, 1948a:40, pl. 7: figs. 15, 16.—Parker, Phleger, and Peirson, 1953:9, pl. 1: figs. 37, 38.—Todd and Bronniman, 1957:26, pl. 2: figs. 24, 25.—Lankford, 1959:2098, pl. 1: fig. 13.—Buzas, Smith, and Beem, 1977:66, pl. 1: figs. 7, 8.

The specimens compare well with the holotype and paratypes, ranging from long and slender to short and squat. Some of the longer individuals tend toward being triserial, but all fit within the range of the numerous paratypes designated by Cushman.

This species is found only south of Sebastian Inlet and is most abundant south of Fort Pierce Inlet.

Figured hypotypes: USNM 310283, 310284. (Total: 158; range: 0–26.)

Genus *Cyclogyra* Wood, 1842

Cyclogyra planorbis (Schultze)

PLATE 1: FIGURE 14

Cornuspira planorbis Schultze, 1854:40, pl. 2: fig. 21.—Phleger and Parker, 1951:8, pl. 4: figs. 8, 9.—Todd and Bronniman, 1957:30, pl. 4: fig. 8.
?*Cornuspira involvens* (Reuss).—Cushman, 1921:62; 1922a:58; 1941:7.—Cushman and Parker, 1931:5, pl. 2: fig. 1.

Our specimens show very little variation, all having three whorls. The small prolocular chamber matches well that of Buzas et al. (1977, unfigured) and Haake (1975, unfigured).

Cyclogyra planorbis is one of the species characteristically occurring at Haulover and the inlets.

Figured hypotype: USNM 310247. (Total: 162; range: 0–67.)

Genus *Edentostomina* Collins, 1958

Edentostomina cultrata (Brady)

PLATE 1: FIGURES 15, 16

Miliolina cultrata Brady, 1884:161, pl. 5: figs. 1, 2.
Quinqueloculina cultrata (Brady).—Todd and Bronniman, 1957:27, pl. 3: fig. 14.—Parker, Phleger, and Peirson, 1953:12, pl. 2: figs. 7, 8.—Lankford, 1959:2099, pl. 1: fig. 15.
Edentosomina cultrata (Brady).—Haake, 1975:19, pl. 1: figs. 5, 6.

The specimens deposited in the Cushman collection by Haake are not those illustrated by him but are from the same material.

Our five specimens range from the well-rounded form with no neck (Lankford, 1959) to the keeled form with a long neck (Haake, 1975).

They occur mainly in the southern part of the Indian River.

Figured hypotype: USNM 310248. Hypotypes: USNM 310254, 310255. (Total: 5; range: 0–1.)

Edentostomina cf. *cultrata* (Brady)

The single specimen thus assigned differs from *Edentostomina cultrata* sensu stricto in having longitudinal striations. Unfortunately the specimen was lost during mounting for SEM.

The specimen was found at Buoy 195. (Total: 1; range: 0–1.)

Genus *Weisnerella* Cushman, 1933

Weisnerella auriculata (Egger)

PLATE 1: FIGURE 17

Planispirina auriculata Egger, 1893:245, 246, pl. 3: figs. 13–15.—Cushman, 1922a:62, pl. 10: fig. 8; 1929a:93, 94, pl. 22: fig. 3.

Weisnerella auriculata (Egger).—Cushman 1933a:33, pl. 3: figs. 7–9.—Parker, 1954:501, 502, pl. 5: fig. 13.

Our specimens match well the specimens in the Cushman collection. This widely distributed species is remarkable in its invariant appearance.

This species was found only at the St. Lucie transect.

Figured hypotype: USNM 310279. (Total: 17; range: 0–5.)

Genus *Spiroloculina* d'Orbigny, 1826

Spiroloculina depressa d'Orbigny

PLATE 2: FIGURES 1, 2

Spiroloculina depressa d'Orbigny, 1826:298; "Modèle" no. 92.—Bandy, 1956:197, pl. 29: fig. 2.

Our single specimen has a bifid tooth and a small opposing simple tooth, just as many of the examined topotypes. Although Bandy's figured specimen does not have the opposing tooth, many specimens from the same study do.

The specimen was found at Jensen Beach.

Figured hypotype: USNM 310276. (Total: 1; range: 0–1.)

Genus *Quinqueloculina* d'Orbigny, 1826

Quinqueloculina agglutinans d'Orbigny

PLATE 2: FIGURES 3–6

Quinqueloculina agglutinans d'Orbigny, 1839a:195, pl. 12: figs. 11–13.—Cushman, 1929a:22, pl. 1: fig. 1.—Bandy, 1956:196.—Todd and Bronniman, 1957:27, pl. 3: fig. 4.—Bock, 1971:16, pl. 4: figs. 3–5.

Our specimens are smaller than most of the specimens in the Cushman collection and have tests composed of better-sorted sand grains. Only a few of the specimens have the bifid tooth common to the larger specimens deposited in the Cushman collection.

A few scattered specimens were found throughout the Indian River.

Figured hypotypes: USNM 310260, 310261. (Total: 14; range: 0–3.)

Quinqueloculina cf. *akneriana* d'Orbigny

PLATE 2: FIGURES 7, 8

The specimens referred to this category are smaller than the topotypes in the Cushman collection and generally have sharper peripheries. Some approach the almost stellate appearance of *Quinqueloculina lamarkiana* but as a group are closer to *Q. akneriana*. Although there is one small topotype in the Cushman collection that seems to be conspecific with our specimens, the general ranges of the two groups do not overlap.

This species was found only south of Fort Pierce Inlet.

Figured specimen: USNM 310262. (Total: 19; range: 0–4.)

Quinqueloculina cf. *bidentata* d'Orbigny

PLATE 2: FIGURES 9, 10

Our specimens are finer grained than most of those in the Cushman collection. The surface has some attached grains and the small bifid tooth shown in d'Orbigny's drawings and in the micrographs of Le Calvez's topotypes (1977).

This species was found in three replicates, two from Herman's Bay and one from Jensen Beach.

Figured specimen: USNM 310263. (Total: 9; range: 0–5.)

Quinqueloculina carinata-striata (Weisner)

PLATE 2: FIGURES 11–13

Adelosina milletti Weisner var. *carcinata-striata* Weisner, 1923:76, 77, pl. 44: figs. 190, 191.

Although we have not examined any specimens of this species, Weisner's drawing is very good and leaves little doubt as to the conspecificity of our specimens. The specimens are heavily costate with an angled periphery. The costae are not parallel to the periphery but meet at it to form a small keel. The aperture is round with a small simple tooth.

Five individuals were found throughout the Indian River.

Figured hypotype: USNM 310264. Hypotypes: USNM 310308, 310309. (Total: 5; range: 0–2.)

Quinqueloculina goesi (Weisner)

PLATE 2: FIGURES 14–17

Miliolina goesi Weisner, 1923:52, 53, pl. 7: fig. 79.
Quinqueloculina goesi (Weisner).—Haake, 1975:33, 34, pl. 3: figs. 58, 59, pl. 4: figs. 60–66.

The type figure of this species shows a specimen with chambers that have a rectangular cross section. Although some of the specimens illustrated by Haake have a similar rectangular cross section, others are more rounded. The specimens deposited in the Cushman collection by Haake range in form from rounded to sub-rounded. Only a few of our specimens displayed the rounded cross section; most have the rectangular cross section that is more typical of the species.

Most of the specimens were found at Herman's Bay; a few were found in the northern portion of the Indian River.

Figured hypotypes: USNM 310265, 310266. (Total: 20; range: 0–5.)

Quinqueloculina gualtieriana d'Orbigny

PLATE 3: FIGURES 1, 2

Quinqueloculina gualtieriana d'Orbigny, 1839a:186, pl. 11: figs. 1–3.

There are no figured specimens of this species from the Atlantic in the Cushman collection. Our specimens, however, match the SEM of Le Calvez (1977) and d'Orbigny's figures, their long, thin simple tooth being characteristic.

Two representatives of this species were found in one replicate from St. Lucie Inlet.

Figured hypotype: USNM 310267. (Total: 2; range: 0–2.)

Quinqueloculina impressa Reuss

FIGURE 23; PLATE 3: FIGURES 3, 4

Quinqueloculina impressa Reuss, 1851:87, pl. 7: fig. 59.—Haake, 1975:24, pl. 1: figs. 24, 25.

Our specimens have a well-rounded outline, both in side view and in apertural view. Some authors have listed similar forms as *Quinqueloculina akneriana* or *Q. lamarkiana*, but examination of

FIGURE 23.—*Quinqueloculina impressa*, front view, USNM 310299, hypotype, × 240.

topotypes shows *Q. impressa* to be much more rounded than either.

Surprisingly, this common Indian River miliolid has not been described from elsewhere in Florida or even from the east coast of North America (Culver and Buzas, 1980).

Figured hypotypes: USNM 310268, 310299. Hypotypes: USNM 310298, 310300, 310301, 310302, 310303, 310304, 310305, 310306, 310307. (Total: 961; range: 0–92.)

Quinqueloculina poeyana d'Orbigny

PLATE 3: FIGURES 5, 6

Quinqueloculina poeyana d'Orbigny, 1839a:191, pl. 11: figs. 25–27.—Cushman, 1921:67, fig. 9, pl. 16: figs. 7, 8; 1929a:31, pl. 5: fig. 2.—Parker, Phleger, and Peirson, 1953:12, pl. 2: figs. 13, 14.—Bandy, 1956:196, pl. 29: fig. 6.—Todd and Bronniman 1957:27, pl. 3: fig. 6.—Todd and Low, 1971:c-8, pl. 2: fig. 4.

This widely distributed species tends to be rather small in most of our samples. Most of our specimens have a long simple tooth with a bifid tip like the neotype designated by Le Calvez (1977). D'Orbigny described the species as having a simple tooth. The specimens in the Cushman collection have teeth that range from bifid to almost no tooth at all.

Most of the specimens were found in the southern half of the Indian River.

Figured hypotype: USNM 310269. (Total: 46; range: 0–11.)

Quinqueloculina seminula (Linné)

PLATE 3: FIGURES 7, 8

Serpula seminula Linné, 1758:786.

Quinqueloculina seminula (Linné).—Cushman 1917:44, 45, fig. 29, pl. 11: fig. 2; 1929a:24, 25, pl. 2: fig. 2; 1929b:59, 60, pl. 9: fig. 18; 1944:13, pl. 2: fig. 14.—Parker, Phleger, and Peirson, 1953:12, pl. 2: figs. 18, 19.—Parker, 1952a:406, pl. 3: fig. 21, pl. 4: fig. 1; 1952b:456, pl. 2: fig. 7.—Todd and Bronniman, 1957:27, pl. 3: figs. 9, 10.—Todd and Low, 1961:15, pl. 1: fig. 14.—Buzas, 1965a:56, pl. 1: fig. 6.

Most of the specimens of this species are rather small, with many of them having transluscent rather than porcelanous walls. Some of them approach the form Haake (1975) called *Quinqueloculina pygmaea*. However, having examined a large number of specimens over a wide size range, there can be little doubt that the abundant and widely distributed *Q. seminula* appears in large numbers throughout the Indian River.

Figured hypotype: USNM 310270. (Total: 1297; range: 0–192.)

Quinqueloculina cf. *striata* d'Orbigny

PLATE 3: FIGURES 9, 10

Two specimens with very fine striations were referred to this category. They are less elongate than *Quinqueloculina striata* sensu stricto.

One specimen is from Buoy 195; the other is from Jensen Beach.

Figured specimen: USNM 310271. (Total: 2; range: 0–1.)

Quinqueloculina tenagos Parker

PLATE 3: FIGURES 11, 12

Quinqueloculina costata d'Orbigny, 1826:301.—Cushman, 1922a:66, 67, pl. 11: fig. 5; 1929a:31, pl. 3: fig. 7.

Quinqueloculina rhodiensis Parker in Parker, Phleger, and Peirson, 1953:12, pl. 2: figs. 15–17.

Quinqueloculina tenagos Parker, 1962:110.

Eight specimens were referred to this category. They are all heavily costate; some have a short neck. The aperture is circular and contains a small short bifid tooth. This species is overall shorter and more rounded in outline than *Quinqueloculina poeyana*.

Figured hypotype: USNM 310272. (Total: 8; range: 0–3.)

Quinqueloculina species

PLATE 3: FIGURES 13, 14

The aperture of this species is about one-fifth of the way from the end of the elongate test and includes a very small bifid tooth. In apertural view the test is slightly stellate.

Both specimens thus referred are from Jensen Beach.

Figured specimen: USNM 310273. (Total: 2; range: 0–2.)

Genus *Massilina* Schlumberger, 1893

?Massilina species

PLATE 3: FIGURES 15, 16

The single specimen thus referred is not compressed as Loeblich and Tappan (1964) define the genus. It does, however, have a bifid tooth, early quinqueloculine chambers, and later chambers added in a single plane.

The specimen was found at Jim's Flat.

Figured specimen: USNM 310249. (Total: 1; range: 0–1.)

Genus *Pateoris* Loeblich and Tappan, 1953

Pateoris dilitata (d'Orbigny)

PLATE 4: FIGURES 1, 2

Quinqueloculina dilitata d'Orbigny, 1839a:192, pl. 11: figs. 28–30.—Cushman, 1921:67, figs. 7, 8, pl. 16: figs. 5, 6; 1922a:69, pl. 12: fig. 2; 1929a:26, pl. 2: fig. 5.

Three battered representatives of this species were found at the St. Lucie Inlet.

Figured hypotype: USNM 310258. (Total: 3; range: 0–3.)

Genus *Triloculina* d'Orbigny, 1826

Triloculina cf. *trigonula* (Lamarck)

PLATE 4: FIGURES 3, 4

The specimens referred to this category match very well those of *Triloculina* cf. *trigonula* collected by Cushman from Cape Canaveral and referred to by Todd (1979). They are much more rounded than *T. trigonula* sensu stricto but have a similar aperture with a large bifid tooth.

The nine specimens referred to this category were all collected south of Fort Pierce Inlet. Seven of the specimens were found in a single replicate from Herman's Bay.

Figured specimen: USNM 310277. (Total: 9; range: 0–7.)

Genus *Miliolinella* Weisner, 1931

Miliolinella subrotunda (Montagu)

PLATE 4: FIGURES 5, 6

Vermiculum subrotundum Montagu, 1803:521.

Miliolinella subrotunda (Montagu).—Loeblich and Tappan, 1964:c466, 467, pl. 355: fig. 1.—Haake, 1975:39, 40, pl. 5: figs. 94–97.

Miliolinella labiosa (d'Orbigny).—Todd and Bronniman, 1957:28, pl. 3: figs. 21, 22.

Miliolinella subrotunda is a species that shows much variation. The tests are generally triloculine in structure, but in our specimens they seem to range in form to quinqueloculine. According to Loeblich and Tappan (1964), this would put those specimens into the genus *Scutuloris*. We see a smooth merge from one form to another in our specimens.

Our specimens all have terminal apertures that contain a flap. Some have lips on the aperture. All are smoothly rounded, although some are fairly elongate. As mentioned above, some are trioculine, some are quinqueloculine, and others are in between.

All but one of our specimens were found at the Haulover Canal station.

Figured hypotype: USNM 310250. Hypotypes: USNM 310251, 310252, 310253. (Total: 7; range: 0–3.)

Miliolinella cf. *subrotunda* (Montagu)

PLATE 4: FIGURES 7, 8

A single specimen was thus referred. It differs from *Miliolinella subrotunda* sensu stricto in that it possesses light longitudinal costae. It may indeed be *M. subrotunda* sensu stricto, but we see no gradation to this form.

The specimen was found at Haulover Canal.

Figured specimen: USNM 310256. (Total: 1; range: 0–1.)

?Miliolinella species

Plate 4: figures 9, 10

The overall outline of the single specimen thus referred is similar to that of *Miliolinella fictellina*, but the aperture is turned sideways, similar to that of *Weisnerella*. The aperture is nearly filled by a large bifid tooth. The margin is acute, and the surface is smooth.

The specimen was found in the St. Lucie transect.

Figured specimen: USNM 310257. (Total: 1; range: 0–1.)

Genus *Biloculinella* Weisner, 1931

Biloculinella globula (Bornemann)

Plate 4: figures 11, 12

Biloculina globulus Bornemann, 1855:349, pl. 19: fig. 3.
Biloculinella globula (Bornemann).—Todd, 1966:24, pl. 17: fig. 11.—Todd and Low, 1967:20, pl. 2: fig. 14.

This bilocular miliolid has a large apertural flap instead of the bifid tooth of *Pyrgo*.

A few specimens were found at Herman's Bay and Jensen Beach.

Figured hypotype: USNM 310246. (Total: 9; range: 0–4.)

Genus *Scutuloris* Loeblich and Tappan, 1953

Scutuloris species

Plate 4: figures 13, 14

The specimens referred to this category are very similar to *Quinqueloculina impressa* but have a slitlike aperture instead of a bifid tooth. There is no well-developed flap in the aperture, but the specimens seem best referred to *Scutuloris*. As mentioned under *Miliolinella subrotunda*, Loeblich and Tappan (1964) define *Miliolinella* and *Scutuloris* as differing only in that the former is triserial and the latter is quinqueloculine. Although we include some quinqueloculine forms in *Miliolinella*, we do not see any triloculine forms, or even any forms tending toward trioculine, in the specimens we are referring to *Scutuloris*.

Most of the specimens were found south of Fort Pierce Inlet.

Figured specimen: USNM 310274. Mentioned specimen: USNM 310275. (Total: 11; range: 0–4.)

Genus *Tubinella* Rhumbler, 1906

?Tubinella species

Plate 4: figure 15

The specimens thus referred are broken and do not show the uniserial portion of the test at all well; hence, the tentative assignment.

All four specimens were found at Jim's Flat.

Figured specimen: USNM 310278. (Total: 4; range: 0–3.)

Genus *Articulina* d'Orbigny, 1826

Articulina cf. *pacifica* Cushman

Plate 4: figure 16

Our single specimen is only very slightly costate, unlike Cushman's types from Fiji, which have rather heavy costae. It does have the same wide lip and overall shape as Cushman's smaller, two-chambered paratype. In offshore samples we have found specimens that are costate and are *Articulina pacifica* sensu stricto, and perhaps our specimen is merely a smooth form.

The single specimen was found at Jensen Beach.

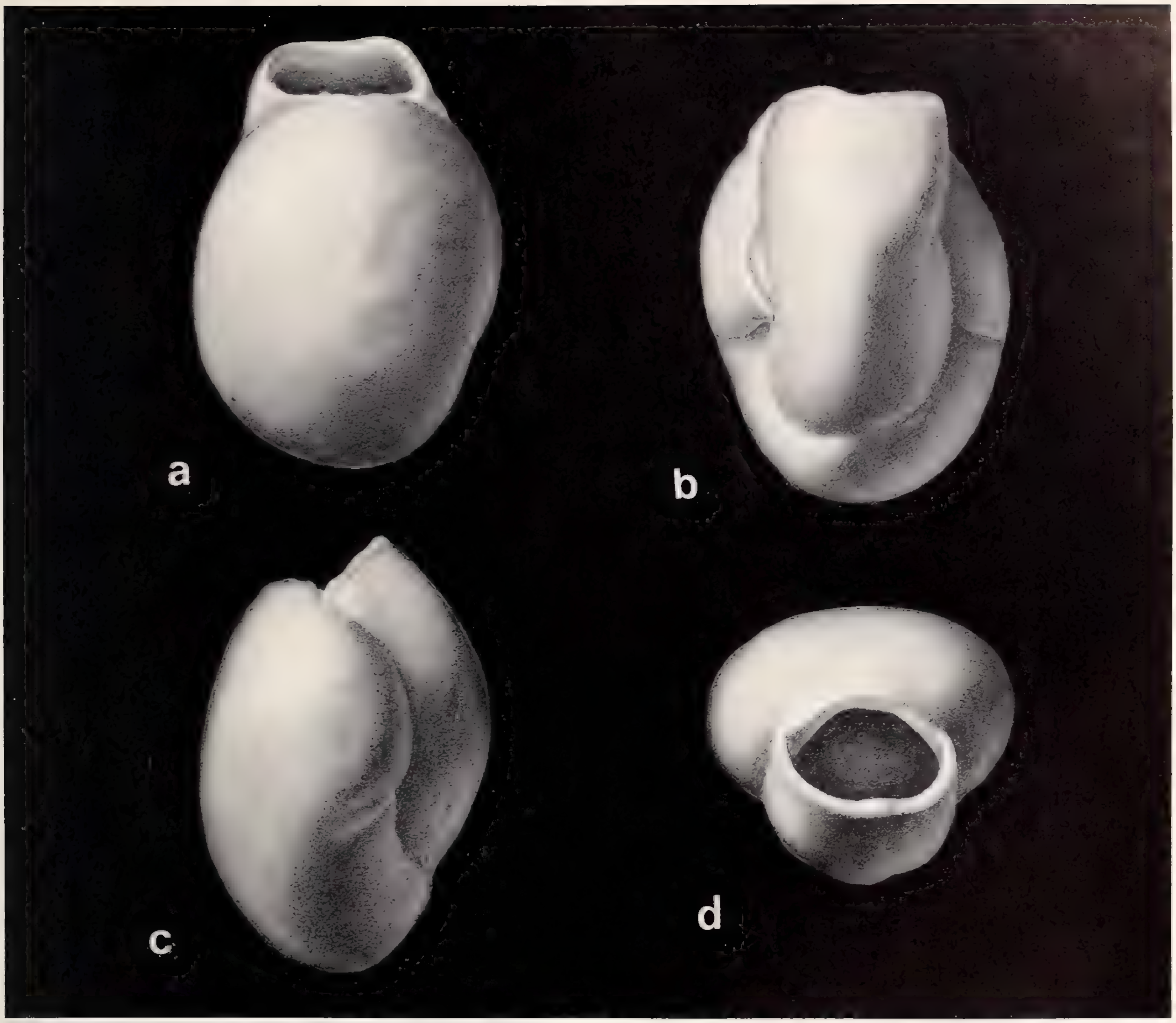
Figured specimen: USNM 310245. (Total: 1; range: 0–1.)

Ishamella, new genus

Test free; chambers inflated, two in number, closely appressed; septum vestigal; wall calcareous, imperforate; aperture terminal.

This simply constructed genus may be related to *Tubinella*. Like *Tubinella*, the proloculus is large, with the second chamber closely appressed, and it has a vestigal septum. Unlike *Tubinella*, it lacks any final tubular chambers.

The genus is named for Lawrence B. Isham,



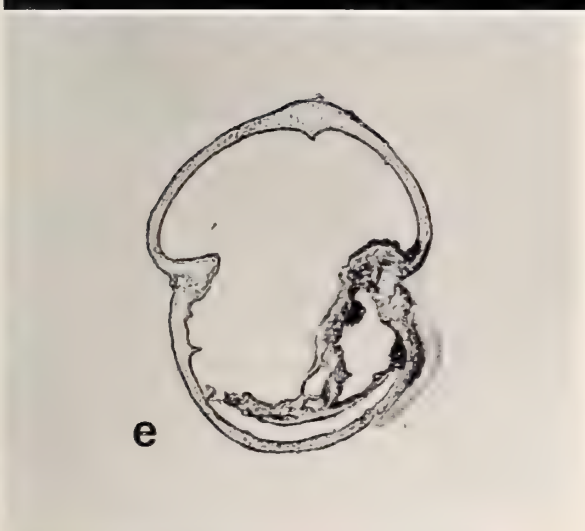


FIGURE 24.—*Ishamella apertura*, USNM 310310, holotype, × 240: *a*, front view; *b*, back view; *c*, side view; *d*, apertural view; *e*, transverse section.

who, with his excellent drawings of foraminifera, has contributed more to foraminiferal taxonomy than words can say.

Gender: feminine.

Type-Species.—*Ishamella apertura*, new species.

Ishamella apertura, new species

Figure 24

Test small; chambers inflated, two in number consisting of proloculus and closely, appressed second chamber, proloculus about twice as large as second chamber, proloculus sometimes with slight folds; septum vestigal; wall calcareous, imperforate, translucent milky color when dry, hyaline when wet; aperture terminal, large, ovate, with a slightly thickened lip.

Figure 24*a–d* comprises drawings of the holotype of *Ishamella apertura*. Figure 24*e*, a transverse section of *I. apertura*, shows the vestigal septum at the junction of the two chambers. The specific name is derived from the large and prominent aperture of the species.

In all, 79 specimens of *I. apertura* were found in the Indian River. The total number of individuals of *I. apertura* is only slightly less than that of *Ammobaculites exilis*, the least abundant of the 15 most abundant species. Other species with similar densities occur at several areas within the Indian River. With the exception of a single individual found at St. Lucie Inlet, all individuals of *I. apertura* were found at Jim's flat. Perhaps this is a newly arrived or newly evolved species. In any case, the extremely localized distribution of this species is unusual.

The length, width, and thickness in millimeters of the holotype is .27, .19, and .18, respectively. The mean and standard deviation for 12 paratypes are given below.

	Mean	*Standard deviation*
Length	.24	.03
Width	.17	.03
Thickness	.15	.04

Holotype: USNM 310310. Paratypes: USNM 310311, 310312, 310313, 310314. (Total: 79; range: 0–67.)

Genus *Peneroplis* Montfort, 1808

Peneroplis pertusus (Forskål)

Plate 5: figure 1

Nautilus pertusus Forskål, 1775:125.—Brady, 1884:204, pl. 13: figs. 16, 17, 23.

Peneroplis pertusus (Forskål).—Cushman, 1921:75, pl. 18: figs. 7, 8; 1930:35, pl. 12: figs. 3–6.—Bock, 1971:34, pl. 13: fig. 10.

None of our specimens were uncoiling; however, they match Cushman's specimens well.

All specimens of this species were found at St. Lucie Inlet.

Figured hypotype: USNM 310259. (Total: 7; range: 0–3.)

Genus *Sorites* Ehrenberg, 1839

Sorites marginalis (Lamarck)

Orbulites marginalis Lamarck, 1816:196.

Sorites marginalis (Lamarck).—Cushman, 1930:49, 50, pl. 18: figs. 1–4.—Bock, 1971:36, 37, pl. 14: figs. 5, 6.

All representatives of this species were found at St. Lucie Inlet or St. Lucie transect, the southernmost areas in the river. This species is common near Miami (Bock, 1971); thus the Indian River may be near the northern range boundary of the species.

(Total: 5; range: 0–3.)

Genus *Lagena* Walker and Jacob

Lagena cf. *doveyensis* Haynes

Plate 5: figure 2

Our specimens are similar to those described by Haynes (1973:82, 83, pl. 12: figs. 7, 8). The specimens have long slender tests that taper gradually to a neck. The end of the neck may have a phialine lip; however, the neck on our specimens is so delicate that the lip is frequently broken. Our specimens differ from Haynes' in that his specimens are much larger and have about 20 striations around the base of the test, whereas ours have only about 15, and in that our speci-

mens have a flattened, not rounded, base on the test.

All our specimens were found in the southern part of the Indian River.

Figured specimen: USNM 310182. (Total: 10; range: 0–3.)

Optically: radial.

Genus *Fissurina* Reuss, 1850

Fissurina lucida (Williamson)

PLATE 5: FIGURE 3

Entosolenia marginata (Montagu) var. *lucida* Williamson, 1848:17, 18, pl. 2: fig. 17.
Fissurina lucida (Williamson).—Loeblich and Tappan, 1953:76, 77, pl. 14: fig. 4.—Todd and Low, 1967:28, pl. 3: fig. 31.

This small species has a very distinctive clear area in the center of the test, surrounded by a frosted horseshoe-shaped margin. The test is slightly compressed with a rounded margin. A few specimens have a very small spine opposite the aperture, as does the specimen of Todd and Low.

Although none of the figured specimens in the Cushman collection are from the Florida area, the species was reported on the Southeastern Continental Shelf by Wilcoxon (1964).

Scattered specimens were found throughout the Indian River.

Figured hypotype: USNM 310183. (Total: 29; range: 0–5.)

Optically: radial.

Fissurina species

PLATE 5: FIGURE 4

A single specimen with an elongate and well-rounded test is referred to this category. The surface of the test is frosted and opaque.

The specimen was found in the St. Lucie transect.

Figured specimen: USNM 310184. (Total: 1; range: 0–1.)

Optically: radial.

Genus *Buliminella* Cushman, 1911

Buliminella elegantissima (d'Orbigny)

PLATE 5: FIGURE 5

Bulimina elegantissima d'Orbigny, 1839b:51, pl. 7: figs. 13, 14.
Buliminella elegantissima (d'Orbigny).—Cushman and Parker, 1931:13, pl. 3: figs. 12, 13.—Phleger and Parker, 1951:17, pl. 8: figs. 3, 4.—Parker, Phleger, and Pierson, 1953:6, 7, pl. 4: figs. 8, 9.—Bandy, 1956:193.—Todd and Bronniman, 1957:32, pl. 8: figs. 1, 2.—Lankford, 1959:2097, pl. 2: fig. 16.—Buzas, Smith, and Beem, 1977:71, 72, pl. 1: figs. 19, 20.

In addition to the above specimens, many unfigured specimens in the Cushman collection have been examined and found to be conspecific.

This widespread species is found in greatest abundance near the inlets, suggesting it is an open-water species.

Figured hypotype: USNM 310214. (Total: 1257; range: 0–118.)

Optically: radial.

Genus *Bolivina* d'Orbigny, 1839

Bolivina cf. *compacta* Sidebottom

PLATE 5: FIGURE 6

Only one specimen was referred to this category. It has no striations, is coarsely perforate, and is rather inflated. Although it might be considered an extreme form of *Bolivina striatula*, it is probably better referred to *B.* cf. *compacta*, as we see no gradation to this form.

The specimen was collected at Link Port.

Figured specimen: USNM 310192. (Total: 1; range: 0–1.)

Optically: radial.

Bolivina paula Cushman and Cahill

PLATE 5: FIGURE 7

Bolivina paula Cushman and Cahill in Cushman and Ponton, 1932:84, pl. 12: fig. 6.—Cushman, 1937:91, pl. 11: fig. 9.—Cushman and McGlamery, 1938:107, 108, pl. 25: figs. 14, 18, 19.—Parker, 1954:516, pl. 7: fig. 26.—Buzas, Smith, and Beem, 1977:74, pl. 2: figs. 1, 2.

A few of our specimens are opaque like the holotype, but most are translucent to transparent. Perhaps the opacity of these specimens is due to weathering, particularly for the holotype, named from the Miocene. All specimens have flush arcuate sutures that do not cross the median. The periphery is smoothly rounded. Most specimens flair rapidly. Although most of our specimens have few pores, those pores that exist are concentrated along the sutures, as they are on the holotype.

Most of the specimens referred to this species were found south of Fort Pierce Inlet.

Figures hypotype: USNM 310193. (Total: 34; range: 0–11.)

Optically: radial.

Bolivina striatula Cushman

Plate 5: figure 8

Bolivina striatula Cushman, 1922a:27, 28, pl. 3: fig. 10; 1941:10.—Parker, Phleger, and Peirson, 1953:6, pl. 4: figs. 4, 5.—Bandy, 1954:135, 136, pl. 31: fig. 9; 1956:193.—Todd and Bronniman, 1957:34, pl. 8: figs. 12–16.—Lankford, 1959:2097, pl. 3: fig. 6.—Buzas, Smith, and Beem, 1977:75, 76, pl. 2: figs. 5–10.

Although this species shows much variation, it forms a distinct species. Most specimens have parallel sides and slightly depressed sutures, giving a slightly lobate periphery. The margin is well rounded; the test is compressed.

Smaller specimens tend to flair slightly; it seems that only the later chambers are added in parallel fashion. The test is usually transparent, although extremely dense striations, particularly near the base, may make the test opaque. The striations are most prominent on the initial third of the test. Only a few of the specimens were totally lacking in striations; Buzas, Smith, and Beem (1977) reported as many as a third to be nonstriate.

Although this species is common throughout the Indian River, it is most abundant in the southern portion.

Figured hypotype: USNM 310194. (Total: 2462; range: 0–271.)

Optically: radial.

Bolivina subexcavata Cushman and Wickenden

Plate 5: figure 9

Bolivina subexcavata Cushman and Wickenden, 1929:9, pl. 4: fig. 4.—Todd and Bronniman, 1957:34, pl. 8: fig. 29.—Buzas, Smith, and Beem, 1977:76–78, pl. 2: figs. 11–22.

Bolivina plicatella Cushman.—Cushman and Parker, 1931:15, 16, pl. 3: fig. 19.—Cushman, 1937:89, pl. 11: figs. 3,4.

Bolivina plicatella var. *mera* Cushman and Ponton.—Todd and Bronniman, 1957:33, pl. 8: fig. 30.

A good discussion of this variable species is given by Buzas, Smith, and Beem (1977). Our specimens generally have slowly tapering biserial tests composed of about 10–12 chambers. The surface of the chambers is rough, giving the specimens a frosted appearance. The sutures are depressed and only slightly, if at all, curved. Some of the specimens have fine longitudinal striations, particularly on the early portion of the test.

Most of the specimens thus referred were found at Buoy 195 and the St. Lucie Inlet.

Figured hypotype: USNM 310195. (Total: 49; range: 0–6.)

Optically: radial.

Bolivina sp. A

Plate 5: figure 10

The test is long and narrow. The chambers are inflated, and the sutures are slightly depressed. The pores are fine and concentrated on the lower half of the chambers, making them almost opaque. The earliest chambers are almost completely covered with pores.

The specimens are similar to the middle Oligocene topotypes of *Bolivina beyrichi* Reuss, but the later are more compressed and flair more.

This species was found at only one station of the Buoy 195 transect.

Figured specimen: USNM 310196. (Total: 3; range: 0–3.)

Optically: radial.

Bolivina sp. B

Plate 5: figure 11

Our specimens are translucent with moderately depressed sutures and inflated chambers. Most of

the specimens are parallel sided. The chambers have few pores; those present are concentrated along the base of the chambers.

Of the 35 specimens found, 18 occurred at Herman's Bay and Jensen Beach, where they were part of the group that composed 95% of the total living population.

Figured specimen: USNM 310197. (Total: 35; range: 0–6.)

Optically: radial.

Genus *Bulimina* d'Orbigny, 1826

Bulimina acculeata d'Orbigny

PLATE 5: FIGURE 12

Bulimina acculeata d'Orbigny, 1826:269.—Cushman and Parker, 1938:92, pl. 6: figs. 9, 10.—Phleger, 1939:1403, pl. 3: fig. 24.—Cushman, 1944:28, pl. 3: fig. 47.—Phleger and Parker, 1951:15, pl. 7: fig. 23.

The topotypes in the Cushman collection (Cushman and Parker, 1938) are larger and more opaque than any of our specimens. However, our specimens have the radiating spines that are common to this species and which serve to differentiate it from *Bulimina marginata* d'Orbigny, which has serrated margins on its chambers.

Most of our specimens were found at Herman's Bay.

Figured hypotype: USNM 310209.(Total: 13; range: 0–5.)

Optically: radial.

Genus *Pavonina* d'Orbigny, 1826

?Pavonina species

PLATE 5: FIGURE 13

A single small specimen is tentatively referred to *Pavonia*. It has the low arched chambers and radial wall structure common to the genus but is very finely perforate. Owing to its small size, it is difficult to tell whether or not the specimen has the initial triserial stage of the genus.

The specimen was found at St. Lucie Inlet.

Figured specimen: USNM 310233. (Total: 1; range: 0–1.)

Optically: radial.

Genus *Hopkinsina* Howe and Wallace, 1932

Hopkinsina pacifica Cushman

PLATE 5: FIGURE 14

Hopkinsina pacifica Cushman, 1933b:86, pl. 8: fig. 16.—Todd and Bronniman, 1957:35, 36, pl. 9: figs. 3, 4.

Hopkinsina pacifica var. *atlantica* Cushman, 1944:30, pl. 4: fig. 1.

Hopkinsina pacifica var. *atlantica* Cushman.—Parker, 1952b:451, pl. 4: figs. 14–16.

Although some authors have called the Atlantic version of *Hopkinsina pacifica* a subspecies, we prefer to follow the approach of Todd and Bronniman (1957): ". . .the difference between populations is not of subspecific rank." The holotype of *H. pacifica* and the holotype and paratypes of *H. pacifica* var. *atlantica* all appear conspecific with our specimens, although some of our specimens are not so twisted as most of the primary types.

This species occurs only in the southern portion of the Indian River.

Figured hypotype: USNM 310190. (Total: 70; range: 0–17.)

Optically: radial.

Hopkinsina cf. *pacifica* Cushman

PLATE 5: FIGURE 15

Two specimens are referred to this category. Although they match *Hopkinsina pacifica* sensu stricto in overall shape and surface texture, they are extremely compressed laterally, perhaps to the point of being strictly biserial.

Both specimens were found at Jensen Beach.

Figured specimen: USNM 310191. (Total: 2; range: 0–1.)

Optically: radial.

Genus *Trifarina* Cushman, 1923

Trifarina occidentalis (Cushman)

PLATE 5: FIGURE 16

Uvigerina angulosa Cushman, 1922a:34, pl. 5: figs. 3–4.

Uvigerina occidentalis (Cushman).—Cushman, 1923:169, 170.

Angulogerina occidentalis (Cushman).—Todd and Bronniman, 1957:36, pl. 9: figs. 5, 6.

Trifarina occidentalis (Cushman).—Buzas, Smith, and Beem, 1977:82, pl. 3: figs. 7–10.

Most of the specimens are rather battered and broken. They are all short and triangular in appearance. None have the long, almost uniserial form identified by Todd and Bronniman (1957, pl. 9: fig. 5).

Figured hypotype: USNM 310210. (Total: 10; range: 0–2.)

Optically: radial.

Genus *Rosalina* d'Orbigny, 1826

Rosalina bulbosa (Parker)

Plate 5: figures 17–19

"Discorbis" bulbosa Parker, 1954:523, pl. 8: figs. 10–12.
Rosalina bulbosa (Parker).—Buzas, Smith, and Beem, 1977:85.

Our specimens match Parker's types well, as well as matching the unfigured specimens of Buzas, Smith, and Beem (1977) from Jamaica. Three of our specimens were found attached, two to miliolids, and one to an *Elphidium mexicanum*.

Scattered specimens were found throughout the Indian River.

Figured hypotypes: USNM 310234, 310235. Hypotype: USNM 310236. (Total: 14; range: 0–1.)

Optically: radial.

Rosalina concinna (Brady)

Plate 6: figures 1, 2

Discorbina concinna Brady, 1884:646, pl. 90: figs. 7, 8.
Discorbis concinnus (Brady).—Bandy, 1956:193, pl. 31: fig. 4.
Rosalina concinna (Brady).—Buzas, Smith, and Beem, 1977:85, 86, pl. 4: figs. 4–6.

This species has a round outline and is fairly compressed. The spiral side has flush sutures. The umbilical side has slightly depressed sutures. There are usually only four chambers visible on the umbilical side, surrounding a small umbilical pit. The final chamber usually covers one-third to one-half of the umbilical side.

Parker's specimens of *Rosalina* cf. *concinna* (Parker, 1954, pl. 8: figs. 17, 18) seem to fit into our suite of specimens without any difficulty.

Scattered specimens were found throughout the Indian River.

Figured hypotype: USNM 310237. (Total: 44; range: 0–7.)

Optically: radial.

Rosalina floridana (Cushman)

Plate 6: figures 5, 6

Discorbis floridana Cushman, 1922a:39, 40, pl. 5: figs. 11, 12; 1931:21, pl. 4: figs. 7, 8.—Cushman and Parker, 1931:18, 19, pl. 4: fig. 5.—Phleger and Parker, 1951:20, pl. 10: fig. 4.
Discorbis floridanus (Cushman).—Bandy, 1954:136, pl. 31: fig. 1.
Rosalina floridana (Cushman).—Parker, 1954:524–525, pl. 8: figs. 19, 20.—Todd and Bronniman, 1957:36, pl. 9: figs. 16–21.—Buzas, Smith and Beem, 1977:86, pl. 4: figs. 7–9.

The most distinctive characteristic of this rosalinid is the overlapping nature of the chambers on the umbilical side. Frequently, the overlapping portions of the chambers form flaps that extend over a deep umbilical pit. The aperture is long, from the umbilical area (generally in the pit) to the periphery. The aperture is low and frequently has a small lip. Our specimens are generally neither as coarsely perforate nor as compressed as those in the Cushman collection but fall well within their range of variation.

This species was most abundant at Vero Beach and Link Port.

Figured hypotype: USNM 310238. (Total: 159; range: 0–39.)

Optically: granular.

Rosalina aff. *floridensis* (Cushman)

Plate 6: figures 3, 4

Our few specimens are distinctive and perhaps are a new species. The test is compressed. The spiral side is coarsely perforate. The chambers fill the umbilical side, making it flat. The sutures are very hard to see on the umbilical side unless the specimen is wet. The umbilical side is covered with a coarse granular layer.

All specimens were found at Vero Beach.

Figured specimen: USNM 310239. (Total: 3; range: 0–2.)

Optically: granular.

Rosalina globularis d'Orbigny

PLATE 6: FIGURES 7, 8

Rosalina globularis d'Orbigny, 1826:271, pl. 13: figs. 1–4.
Discorbis columbiensis Cushman, 1925:43, pl. 6: fig. 13.
Tretomphalus bulloides (d'Orbigny).—Cushman, 1934:86, pl. 11: fig. 2.
Tretomphalus myersi Cushman, 1943:26, pl. 6: figs. 4–6.
Tretomphalus atlanticus Cushman.—Bock, 1971:53, pl. 19: figs. 1–3.

This much-confused species was well described by Douglas and Sliter in 1965. Its considerable variation has led to its taxonomic confusion over the years.

Our specimens tend to have a slightly higher spire than most of those in the Cushman collection but fit well into the range established by Douglas and Sliter (1965). Only one of our specimens had a float chamber.

This species is widely distributed in the Indian River but is most abundant in the southern part.

Figured hypotype: USNM 310240; (Total: 175; range: 0–27.)

Optically: radial.

Rosalina subaraucana (Cushman)

PLATE 6: FIGURES 9–12

Discorbis subaraucana Cushman, 1922a:41, pl. 7: figs. 1, 2; 1931:32, pl. 7: fig. 2.
Discorbis floridana Cushman.—Parker, Phleger, and Peirson, 1953:7, pl. 4: figs. 18, 19.
Rosalina subaraucana (Cushman).—Buzas, Smith, and Beem, 1977:86, 87, pl. 4: figs. 13–15.

Only one representative of this species is large; it matches the specimen of Buzas, Smith, and Beem (1977) very well. The small specimens are more transparent and have very few pores, but the overall shape is identical to that of the single large specimen and those specimens in the Cushman collection.

This species was found mainly at Vero Beach and St. Lucie Inlet.

Figured hypotypes: USNM 310242, 310243. (Total: 32; range: 0–14.)

Optically: radial.

Rosalina juveniles

Some very small trochospiral specimens were put in this category. When a specimen has only three or four chambers, specific, or even generic, placement is almost impossible.

Total: 16; range: 0–5.

Genus *Stetsonia* Parker, 1954

Stetsonia minuta Parker

PLATE 7: FIGURES 1, 2

Stetsonia minuta Parker, 1954:534, 535, pl. 10: figs. 27–29.

Only two specimens of this species were found. Unfortunately one was lost, and the other was heavily gold coated for SEM use.

Both specimens were found at St. Lucie Inlet.

Figured hypotype: USNM 310244. (Total: 2; range: 0–1.)

Optically: radial.

Genus *Glabratella* Dorreen, 1948

Glabratella species

PLATE 7: FIGURES 3, 4

Three compressed specimens from Buoy 195 were referred to this category.

Figured specimen: USNM 310220. (Total: 3; range: 0–3.)

Optically: radial.

Genus *Glabratellina* Seiglie and Bermudez, 1965

Glabratellina sagrai (Todd and Bronniman)

PLATE 7: FIGURES 5, 6

Rosalina sagrai Todd and Bronniman, 1957:37, pl. 9: fig. 22.
Glabratellina sagrai (Todd and Bronniman).—Buzas, Smith, and Beem, 1977:91, pl. 5: figs. 25–27.

Although our specimens generally do not have as high a spire as those mentioned above, they do have the pustules on the umbilical side that are distinctive to this species. They generally have 7–8 chambers visible in the final whorl.

Scattered specimens occur throughout the Indian River.

Figured hypotype: USNM 310221. (Total: 28; range: 0–3.)

Optically: radial.

Genus *Mychostomina* Berthelin, 1881

Mychostomina revertens (Rhumbler)

PLATE 7: FIGURES 7, 8

Spirillina vivipara var. *revertens* Rhumbler, 1906:32, pl. 2: figs. 8–10.

Spirillina vivipara Ehrenberg var. *densepunctata* Cushman.—Cushman and Parker, 1931:18, pl. 4: fig. 1.

?Conicospirillina atlantica Cushman, 1947:91, pl. 20: fig. 8.

Mychostomina revertens (Rhumbler).—Smith and Isham, 1974:66, pl. 1: figs. 1–3, 7–9.—Buzas, Smith, and Beem, 1977:93, pl. 6: figs. 7–12.

Although our specimens do not match any of Smith and Isham's (1974) drawings extremely well, they do match USNM 211312 exactly. This unfigured specimen from Jamaica was selected by Smith for Buzas, Smith, and Beem, 1977. Apparently it represents an extreme form of this species, a form that has many whorls on the spiral side and has only very few very fine pores.

Most of the specimens occur at Vero Beach.

Figured hypotype: USNM 310223. (Total: 11; range: 0–4.)

Optically: radial.

Genus *Ammonia* Brünnich, 1772

Ammonia beccarii (Linné)

PLATE 7: FIGURES 9, 10

Nautilus beccarii Linné, 1758:710.

Rotalia beccarii (Linné).—Cushman, 1922a:52, pl. 8: figs. 7–9; 1928:104, pl. 15: figs. 1–7; 1931:58, pl. 13: figs. 1, 2; 1944:35, pl. 4: fig. 22.—Post, 1951:176.—Parker, 1952b:457, 458, pl. 5: fig. 5.—Parker, Phleger, and Peirson, 1953:13, pl. 4: figs. 20–22, 25–30.

"Rotalia" beccarii (Linné) variants.—Phleger, Parker, and Peirson, 1953:42, pl. 9: figs. 14, 15.—Parker, 1954:531, pl. 10: figs. 1, 2, 5, 6.

Ammonia beccarii (Linné).—Buzas, 1965b:62, pl. 4: fig. 1.

Rosalina parkinsonia d'Orbigny, 1839a:99, pl. 4: figs. 25–27.

Rotalia beccarri (Linné) var. *parkinsonia* (d'Orbigny).—Phleger and Parker, 1951:23, pl. 12: fig. 6.—Bock, 1971:55, 56, pl. 20: figs. 5, 6.

Rotalia beccarii (Linné) var. *tepida* Cushman, 1926:79, pl. 1; 1931:61, pl. 13: fig. 3.—Phleger and Parker, 1951:23, pl. 12: fig. 7.—Post, 1951:176.—Parker, 1952b:457, 458, pl. 5: fig. 8.

Rotalia beccarii (Linné) var. *sobrina* Shupack, 1934:6, 7, fig. 4.—Post, 1951:176.—Parker, 1952b:457, 458, pl. 5: fig. 8.

Although some researchers divide this species into several varieties, we feel that all are found in similar areas or even in the same replicate, and thus we believe that subspecific nomenclature is not warranted.

This is the most abundant species in the Indian River, and it is found throughout the river. Only one station, in the Jensen Beach transect, did not have any members of this species.

Figured hypotype: USNM 310213. (Total: 7468; range: 0–499.)

Optically: radial.

Genus *Elphidium* Montfort, 1808

Elphidium advenum (Cushman)

PLATE 8: FIGURE 1

Polystomella advena Cushman, 1922a:56, 57, pl. 9: figs. 11, 12.

Elphidium advenum (Cushman).—Parker, Phleger, and Peirson, 1953:7, pl. 3: fig. 11.—Parker, 1954:508, pl. 6: fig. 14.—Bandy, 1956:193, pl. 30: fig. 18.—Todd and Bronniman, 1957:39, pl. 6: figs. 5–7.—Bock 1971:56, pl. 20: figs. 7, 8.

Some of our specimens do not have a keel and, at first, could be mistaken for an *Elphidium excavatum* with a glassy umbilicus. However, the two species differ in the shape of their peripheries (that of *E. advenum* is acute, not rounded) and in wall structure. *Elphidium advenum* is granular, not radial. All our specimens have many sutural bridges and fit well within the limits of this species' variation.

Only a few of the specimens referred to this species occur north of Fort Pierce Inlet.

Figured hypotype: USNM 310198. Hypotype: USNM 310199. (Total: 37; range: 0–6.)

Optically: granular.

Elphidium excavatum (Terquem)

Plate 8: figure 2

Polystomella excavata Terquem, 1875:25, pl. 2: fig. 2.
Elphidium incertum var. *clavatum* Cushman, 1930:20, pl. 7: fig. 10.
Elphidium clavatum Cushman.—Loeblich and Tappan, 1953:98, 99, pl. 19: figs. 8–10.—Todd and Bronniman, 1957:39, pl. 6: fig. 10.—Buzas, 1965a:58, 59, pl. 2: figs. 6, 7, pl. 3: figs. 1, 2; 1966:591, pl. 71: figs. 1–8.

Only a few specimens have the "characteristic brown color" of this species, and most of them tend to be smaller than specimens from further north. Our specimens do have the umbilical bosses, sutural bridges, and deep coarse pores characteristic of the species.

This species occurs in low abundance throughout the Indian River but is most abundant at John's Island and St. Lucie Inlet.

Figured hypotype: USNM 310202. Hypotype: USNM 310201. (Total: 493; range: 0–49.)

Optically: radial.

Elphidium galvestonense (Kornfeld)

Plate 8: figure 3

Elphidium gunteri Cole var. *galvestonensis* Kornfeld, 1931:87, pl. 15: fig. 1.—Phleger and Parker, 1951:10, pl. 5: figs. 13, 14.—Bandy, 1954:136, pl. 30: fig. 2.
Elphidium galvestonense (Kornfeld).—Parker, Phleger, and Peirson, 1953:7, 8, pl. 3: figs. 15, 16.

We have examined the specimen designated by Kornfeld as *Elphidium gunteri* var. *galvestonensis* Kornfeld, microspheric form (691), later designated by Parker, Phleger, and Peirson (1953) as a lectotype. It matches our specimens extremely well. Our specimens are large and have an almost porcelanous sheen.

This species occurs mainly in the northern part of the Indian River.

Figured hypotype: USNM 310200. (Total: 26; range: 0–4.)

Optically: radial.

Elphidium gunteri Cole

Plate 8: figure 4

Elphidium gunteri Cole, 1931:34, pl. 4: figs. 9, 10.—Parker, 1954:508, pl. 6: fig. 16.—Bandy, 1956:194, pl. 30: fig. 19.—Lankford, 1959:2098, pl. 2: fig. 7.

This species has deep coarse pores and is frequently brown. The umbilical area is usually filled with many glassy pustules.

This species occurs mostly in the narrow, island-filled portion of the river at the John's Island and Vero Beach stations.

Figured hypotype: USNM 310203. Hypotype: USNM 310204. (Total: 446; range: 0–53.)

Optically: radial.

Elphidium kugleri (Cushman and Bronniman)

Plate 8: figure 5

Cribroelphidium kugleri Cushman and Bronniman, 1948a:18, 19, pl. 4: fig. 4.

Specimens flair rapidly and have regular septal bridges, as do the primary types. Not all of our specimens are so transparent as the types; instead, some are a milky white, possibly due to etching.

Scattered specimens of this species occur throughout the river.

Figured hypotype: USNM 310205. (Total: 110; range: 0–18.)

Optically: radial.

Elphidium mexicanum Kornfeld

Figure 25; Plate 8: figure 6

Elphidium incertum var. *mexicanum* Kornfeld, 1931:89, pl. 16: fig. 1.

We had the opportunity to examine Kornfeld's types. Our material looks most like Kornfeld's specimen no. 694. Kornfeld's specimen has 12 chambers in the final whorl, but ours usually have from 9 to 11. In his description, he indicated a variation from 10 to 12. The umbilical area on our specimens is usually larger than on Kornfeld's specimen and is often depressed, whereas it is flush on his specimen. Furthermore, our specimens often contain one or more umbilical bosses,

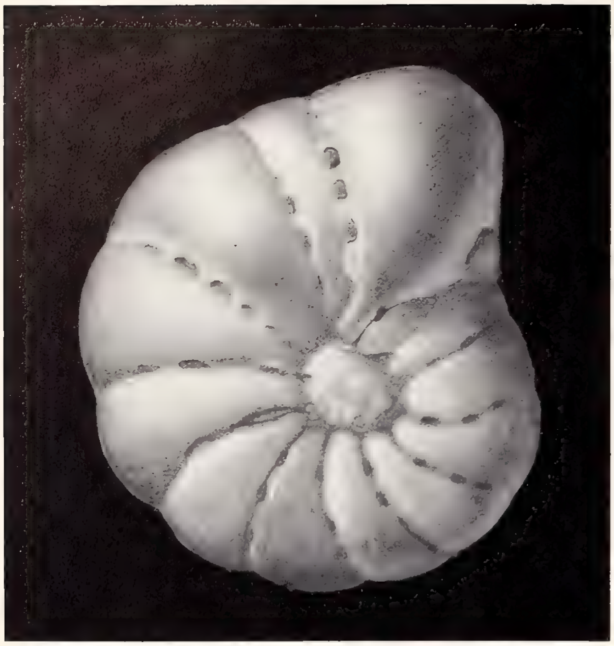


FIGURE 25.—*Elphidium mexicanum*, side view, USNM 310289, hypotype, × 200.

but Kornfeld's type does not. In his description, however, Kornfeld did use the phrase "umbilical region multiple or central," indicating, perhaps, that some of the individuals he examined also had multiple bosses. Despite the differences noted above, we believe our specimens are best referred to *E. mexicanum*.

This species occurs throughout the Indian River but is most abundant at the inlets.

Figured hypotypes: USNM 310288, 310289. Hypotypes: USNM 310290, 310291, 310292, 310293, 310294, 310295, 310296, 310297. (Total: 613; range: 0–74.)

Optically: granular.

Elphidium cf. *mexicanum* Kornfeld

PLATE 8: FIGURE 7

The two specimens that were referred to this category are more compressed and flair more than *Elphidium mexicanum* sensu stricto. Their sutures are curved to a slightly greater degree, and the sutural bridges are much more regular than those of the majority of the *E. mexicanum* sensu stricto specimens. They may represent an extreme form of *E. mexicanum*, but we do not see sufficient gradiation between the two forms.

Both specimens were found in a single Buoy 195 replicate.

Figured specimen: USNM 310207. (Total: 2; range: 0–2.)

Optically: granular.

Elphidium norvangi Buzas, Smith, and Beem

PLATE 8: FIGURE 8

Elphidium norvangi Buzas, Smith, and Beem, 1977:96, pl. 7: figs. 1–4.

A few specimens of this distinctive small *Elphidium* were found. All had the spike-shaped papillae on the apertural face, the unique feature of the species.

Most of the specimens were found at Buoy 195.

Figured hypotype: USNM 310206. (Total: 13; range: 0–2.)

Optically: radial.

Elphidium species

PLATE 8: FIGURE 9

The walls of these specimens are opaque and milky white. The sutures are slightly depressed and crossed by regularly spaced sutural bridges. There are about 16 chambers in the final whorl; they are inflated, making the periphery smoothly rounded.

Two specimens of this granular species were found south of the Fort Pierce Inlet.

Figured specimen: USNM 310208. (Total: 2; range: 0–1.)

Optically: granular.

Genus *Haynesina* Banner and Culver, 1978

Haynesina germanica (Ehrenberg)

PLATE 8: FIGURE 10

Nonionina germanica Ehrenberg, 1840:23; 1841, pl. 2: figs. 1a–g.

Nonion germanicum (Ehrenberg).—Cushman, 1930:8, 9, pl. 3: fig. 5.

Nonion tisburyensis Butcher, 1948:21, 22, figs. 1–3.

Protelphidium tisburyense (Butcher).—Parker and Athearn, 1959:342, pl. 50: figs. 26, 32.
Nonion depressulum var. *matagordanum* Kornfeld.—Bock, 1971:64, pl. 23: fig. 14.
Haynesina germanica (Ehrenberg).—Banner and Culver, 1978, pl. 4: figs. 1–6, pl. 5: figs. 1–8, pl. 6: figs. 1–7, pl. 8: figs. 1–10, pl. 9, figs. 1–11, 15, 18.

The specimens have granular material in the umbilical area and curved, depressed sutures with no sutural bridges. As a group our specimens do not match those of Banner and Culver (1978) exactly, but the two populations show considerable overlap. Our specimens tend to have slightly straighter sutures and slightly less granular material in the umbilical area than do those of Banner and Culver (1978), but we do not consider the difference to be of specific importance.

This widely distributed species was found in low abundance, mostly in the northern half of the Indian River.

Figured hypotype: USNM 310211. (Total: 53; range: 0–11.)

Optically: radial.

Genus *Eponides* de Montfort, 1808

Eponides repandus (Fichtel and Moll)

PLATE 9: FIGURES 1, 2

Nautilus repandus Fichtel and Moll, 1798:35, pl. 3: figs. a–d.
Eponides repanda (Fichtel and Moll).—Cushman 1931:49–51, pl. 10: fig. 7.
Eponides repandus (Fichtel and Moll).—Parker, 1954:529, pl. 9: figs. 27, 28.—Bock, 1971:58, pl. 21: figs. 6, 7.

A few specimens of this well-known open-water species were found near the St. Lucie Inlet.

Figured hypotype: USNM 310219. (Total: 6; range: 0–2.)

Genus *Cibicides* de Montfort, 1808

Cibicides aff. *floridana* (Cushman)

PLATE 9: FIGURES 3, 4

Our four specimens differ from *Cibicides floridana* sensu stricto in having very indistinct sutures and in having a flatter umbilical side.

Three specimens were found at St. Lucie Inlet; the fourth was found at Jensen Beach.

Figured specimen: USNM 310215. (Total: 4; range: 0–3.)

Optically: granular.

Cibicides species

PLATE 9: FIGURES 5, 6

Our two specimens are small with a flattened, but still convex, spiral side. The sutures on the umbilical side are radial and extend to the center of the specimen. The spiral side is coarsely perforate with a depressed spiral sutural line.

Both specimens are from Buoy 195.

Figured specimen: USNM 310216. (Total: 2; range: 0–2.)

Optically: radial.

Genus *Planorbulina* d'Orbigny, 1826

Planorbulina mediterranensis d'Orbigny

PLATE 9: FIGURE 7

Planorbulina mediterranensis d'Orbigny, 1826:280, pl. 14: figs. 4–6 [6 bis.].—Cushman, 1922a:45, 46, pl. 6: figs. 1, 2; 1931:129, 130, pl. 24: figs. 5–8.—Bandy, 1954:137, pl. 31: fig. 3.—Parker, 1954:545, pl. 13: fig. 9.

A single broken representative of this species was found at St. Lucie Inlet.

Figured hypotype: USNM 310189. (Total: 1; range: 0–1.)

Optically: radial.

Genus *Cymbaloporetta* Cushman, 1928

Cymbaloporetta atlantica (Cushman)

PLATE 9: FIGURES 8, 9

Tretomphalus atlanticus Cushman, 1934:86, 87, pl. 11: fig. 3, pl. 12: fig. 7.—Phleger and Parker, 1951:26, pl. 14: fig. 3.
Cymbaloporetta atlantica (Cushman).—Buzas, Smith, and Beem, 1977:101, pl. 7: figs. 22–24.

Two specimens were referred to this species. They are large and have the cymbaloporetoid chambers on the final whorl. Neither has a float chamber as do many of Cushman's specimens.

Our specimens are slightly more inflated than most of those in the Cushman collection.

One specimen was found at Buoy 195, the other at Herman's Bay.

Figured hypotype: USNM 310217. (Total: 2; range: 0–1.)

Optically: radial.

Cymbaloporetta species

PLATE 9: FIGURES 10, 11

A single broken specimen from Herman's Bay is thus referred.

Figured specimen: USNM 310218. (Range: 0–1; total: 1.)

Optically: granular.

Genus *Fursenkoina* Loeblich and Tappan, 1961

Fursenkoina fusiformis (Williamson)

PLATE 10: FIGURE 1

Bulimina pupoides(?) var. *fusiformis* Williamson, 1858:63, figs. 129, 130.

Virgulina fusiformis (Williamson).—Parker, 1952a:417, pl. 19: figs. 5, 6; 1952b:461, pl. 4: fig. 10.

The last three chambers of our specimens make up just less than half the length of the test; Williamson's drawing shows them making up a little more. Our specimens are not so inflated as in the drawing by Williamson but do have the finely perforate walls and triserial to twisted biserial chamber arrangement he describes for the species.

Almost all the specimens occur at Herman's Bay.

Figured hypotype: USNM 310185. (Total: 11; range: 0–5.)

Optically: radial.

Fursenkoina mexicana (Cushman)

PLATE 10: FIGURE 2

Virgulina mexicana Cushman, 1922b:120, pl. 23: fig. 8.—Phleger and Parker, 1951:19, pl. 9: figs. 6–8.—Parker 1954:512, pl. 7: figs. 7, 8.

Fursenkoina mexicana (Cushman).—Bock, 1971:62, pl. 23: fig. 8.

The test of this species is rather compressed and tends toward being biserial. The test generally displays only two or three chambers on one side while displaying all of them, 8–10, on the other. Our specimens are slightly more compressed than the primary types and have slightly more depressed sutures.

This species is most common in the central portion of the Indian River, north and south of Fort Pierce Inlet, but not at the inlet itself.

Figured hypotype: USNM 310186. (Total: 18; range: 0–7.)

Optically: granular.

Fursenkoina pontoni (Cushman)

PLATE 10: FIGURE 3

Virgulina pontoni Cushman, 1932:19, pl. 2: figs. 26–28.—Phleger and Parker, 1951:19, pl. 9: figs. 9, 10.—Parker, Phleger, and Peirson, 1953:15, pl. 4: figs. 14, 15.—Parker, 1954:513, pl. 7: fig. 9.—Lankford, 1959:2099, pl. 2: fig. 17.

Fursenkoina pontoni (Cushman).—Buzas, Smith, and Beem, 1977:102, pl. 8: figs. 7, 8.

This species is compressed laterally and has slightly depressed sutures. It is twisted slightly about its central axis.

The specimens were found near St. Lucie Inlet and at Buoy 195.

Figured hypotype: USNM 310187. (Total: 4; range: 0–2.)

Optically: granular.

Genus *Sigmavirgulina* Loeblich and Tappan, 1957

Sigmavirgulina tortuosa (Brady)

PLATE 10: FIGURE 4

Bolivina tortuosa Brady.—Cushman and Parker, 1931:16, pl. 3: fig. 22.—Cushman, 1937:133, 134, pl. 17: figs. 11–19; 1941:10.—Todd and Bronniman, 1957:34, pl. 8: fig. 24.

Sigmavirgulina tortuosa (Brady).—Buzas, Smith, and Beem, 1977:103, 104, pl. 8: figs. 9–12.

Our single specimen has the twisted test and coarse pores present in the specimens in the Cushman collection.

It was found in the St. Lucie transect.

Figured hypotype: USNM 310188. (Total: 1; range: 0–1.)

Optically: radial.

Genus *Cassidulina* d'Orbigny, 1826

Cassidulina barbara Buzas

PLATE 10: FIGURE 5

Cassidulina barbara Buzas, 1965a:25, 26, pl. 5: figs. 2, 3.
Cassidulina cf. *subglobosa*.—Buzas, Smith, and Beem, 1977:106.

Two specimens of this species were found, one at St. Lucie Inlet and the other at Buoy 195.

Figured hypotype: USNM 310212. (Total: 2; range: 0–1.)

Optically: granular.

Genus *Nonion* de Montfort, 1808

Nonion boueanum (d'Orbigny)

PLATE 10: FIGURES 6, 7

Nonionina boueana d'Orbigny, 1846:108, pl. 5: figs. 11, 12.
Nonion boueanum (d'Orbigny).—Cushman, 1939:12, 13, pl. 3: figs. 7, 8.—Todd and Bronniman, 1957:32, pl. 5: figs. 25, 26.

This rather large *Nonion* has about 14 chambers in the final whorl and has the curved depressed sutures shown in d'Orbigny's drawing and in topotypes in the Cushman collection.

The three specimens were found at Herman's Bay.

Figured hypotype: USNM 310224. (Total: 3; range: 0–2.)

Optically: granular.

Nonion species

PLATE 10: FIGURES 8, 9

The specimens in this category are similar to *Nonion boueanum* in that both species have a round outline, are slightly compressed with an angular, but not sharp, periphery, and have curved sutures. *Nonion* sp. A differs from *N. boueanum*, however, in having flush, not depressed, sutures and in lacking the final greatly inflated chamber common to *N. boueanaum*. The SEM's show some primitive sutural bridges, leading us to suspect the *Nonion* designation.

A few specimens from the stations just north and south of the Fort Pierce Inlet are referred to this category.

Figured specimen: USNM 310225. Mentioned specimen: USNM 310226. (Total: 7; range: 0–3.)

Optically: granular.

Genus *Nonionella* Cushman, 1926

Nonionella atlantica Cushman

PLATE 10: FIGURES 10–12

Nonionella atlantica Cushman, 1947:90, 91, pl. 20: figs. 4, 5.—Todd and Bronniman, 1957:32, pl. 5: figs. 30, 31.

This species has very inflated chambers and a moderate amount of granular material in the umbilical region.

A few specimens of this species were found scattered throughout the Indian River.

Figured hypotype: USNM 310227. (Total: 8; range: 0–3.)

Optically: granular.

Nonionella auricula Heron-Allen and Earland

PLATE 11: FIGURES 1–3

Nonionella auricula Heron-Allen and Earland, 1930:192, pl. 5: figs. 68–70.—Todd and Bronniman, 1957:32, pl. 5: fig. 32.—Buzas, Smith, and Beem, 1977:107.

This species shows a considerable amount of variation. Taxonomic placement of this species is complicated by the poor figure of Heron-Allen and Earland and the misidentification of many of the specimens in the Cushman collection. Many of the specimens in the Cushman collection are either *Nonionella atlantica* or *Nonion grateloupi*.

The larger specimens of this species seem al-

most planispiral. The periphery may be fairly acute but is rounded on most specimens. The chambers are compressed, and the sutures are only slightly depressed. The proloculus is generally visible on the "spiral" side as a large knob, the "umbilical" side usually has little or no granular material in it. In smaller specimens the large prolocular chamber makes the specimen very trochoid; only the larger later chambers tend toward being planispiral.

This species occurs throughout the Indian River but is most abundant in the southern part.

Figured hypotype: USNM 310228. Hypotype: USNM 210229. (Total: 458; range: 0–59.)

Optically: granular.

Nonionella cf. *auricula* Heron-Allen and Earland

PLATE 11: FIGURES 4–6

Three specimens were thus referred. They flair more rapidly than *Nonionella auricula* sensu stricto. The final chambers tend to be very high and long, with very straight sutures. This group seems to be more compressed and less trochospiral than specimens of similar size that were placed in *N. auricula*.

The specimens were found at Buoy 195 and Herman's Bay.

Figured specimen: USNM 310230. Mentioned specimen: USNM 310231. (Total: 3; range: 0–2.)

Optically: granular.

Nonionella opima Cushman

PLATE 11: FIGURES 7–9

Nonionella opima Cushman, 1947:90, pl. 20: figs. 1–3.—Todd and Bronniman, 1957:32, pl. 6: figs. 1, 2.—Parker, Phleger, and Peirson, 1953:11, pl. 3: figs. 32, 33.—Parker, 1954:507, pl. 6: fig. 10–12.—Lankford, 1959:2098, pl. 2: figs. 10–11.

Our specimens have the circular outline and inflated final chamber of this distinctive species. Very few of our specimens have the curved sutures of Cushman's types.

This species appears in low numbers throughout the Indian River.

Figured hypotype: USNM 310232. (Total: 11; range: 0–3.)

Optically: granular.

Genus *Hanzawaia* Asano, 1944

Hanzawaia concentrica (Cushman)

PLATE 11: FIGURES 10, 11

Truncatulina concentrica Cushman, 1918:64, pl. 21: fig. 3.

Cibicides concentrica (Cushman).—Cushman, 1931:120, 121, pl. 21: figs. 4, 5, pl. 22: figs. 1, 2.

Cibicides concentricus (Cushman).—Phleger and Parker, 1951:29, pl. 15: figs. 14, 15.—Parker, 1952b:445, 446, pl. 5: fig. 10.

The holotype of this species is missing; however, the four paratypes designated by Cushman were examined. Our specimens do not have sutures that are as depressed as those of the paratypes but otherwise match extremely well.

All but one of our specimens were collected at St. Lucie Inlet.

Figured hypotype: USNM 310222. (Total: 6; range: 0–2.)

Optically: radial.

Appendix

Number of Living Individuals Observed in 20 ml Replicate Samples

(Localities are shown in Figure 1)

SPECIES	HAULOVER				BANANA			SEBASTIAN				JOHN'S ISLAND								
	1	2	3	4	1	3	4	1	2	3	4	1	1'	2	2'	3	3'	4	4'	5
? ALLOGROMIA						2														
AMMONIA BECCARII	78	29	22	22	30	68	39	35	100	48	90	102	191	137	156	25	28	85	11	54
AMMOBACULITES EXIGUUS																				
AMMOBACULITES EXILIS						4		2		5			2	2						
AMMOBACULITES CF. A. EXILIS																				
ARTICULINA CF. A. PACIFICA																				
BILOCULINELLA GLOBULA																				
BOLIVINA CF. B. COMPACTA																				
BOLIVINA PAULA														2						
BOLIVINA STRIATULA	23	3	1	2				4	7	11	12	18	63	72	40	9	2	2		6
BOLIVINA SUBEXCAVATA												2	3		1					1
BOLIVINA SP. A																				
BOLIVINA SP. B														2						
BULIMINA ACCULEATA																				
BULIMINELLA ELEGANTISSIMA	3			1				1	7	1	5	4	4	25	4	1	1	2		3
CASSIDULINA BARBARA																				
CIBICIDES AFF. C. FLORIDANA																				
CIBICIDES SP																				
CYCLOGYRA PLANORBIS		7	21	1						7										
CYMBALOPORETTA ATLANTICA																				
CYMBALOPORETTA SP. A																				
EDENTOSTOMINA CULTRATA																				
EDENTOSTOMINA CF. E. CULTRATA																				
ELPHIDIUM ADVENUM											1				1					
ELPHIDIUM EXCAVATUM	5	4	6	4	13	1	16	7		12	20	1	14	20	71	5	4	12	4	12
ELPHIDIUM GALVESTONENSE	1	3	4	4	1	3														
ELPHIDIUM GUNTERI			1			12	1	1		2		4	5	84	22				2	1
ELPHIDIUM KUGLERI	2	1	3			2				2				1	2		1			
ELPHIDIUM MEXICANUM	11	9	6	5	1	4		21	38	30	44			4	2		4	2	4	3
ELPHIDIUM CF. E. MEXICANUM																				
ELPHIDIUM NORVANGI																				
ELPHIDIUM SP. A																				
EPONIDES REPANDUS																				
FISSURINA LUCIDA															1	1			1	
FISSURINA SP. A																				
FURSENKOINA FUSIFORMIS																				
FURSENKOINA MEXICANA																				
FURSENKOINA PONTONI																				
GAUDRYINA EXILIS								1		2			1			1				
GLABRATELLA SP																				
GLABRATELLINA SAGRAI													1	2						
HANZAWAIA CONCENTRICA																				
HAYNESINA GERMANICA		1			1		11	1	1	2	1	1		3	3	1				1
HOPKINSINA PACIFICA																				
HOPKINSINA CF. H. PACIFICA																				
ISHAMELLA APERTURA																				
LAGENA CF. L. DOVEYENSIS																				
MASSILINA SP. A																				
MILIOLINELLA SUBROTUNDA		2	3	1																
MILIOLINELLA CF. M. SUBROTUNDA			1																	
? MILIOLINELLA SP. A																				
MYCHOSTOMINA REVERTENS		1																		
NONION BOUEANUM																				
NONION SP																				
NONIONELLA ATLANTICA															3					
NONIONELLA AURICULA			1						4	8				3		1				
NONIONELLA CF. N. AURICULA																				
NONIONELLA OPIMA														2	1					
PATELLORIS DILITATA																				
? PAVONINA SP																				
PENEROPLIS PERTUSUS																				
PLANORBULINA MEDITERRANENSIS																				
QUINQUELOCULINA AGGLUTINANS						1														
QUINQUELOCULINA CF. Q. AKNERIANA																				
QUINQUELOCULINA CF. Q. BIDENTATA																				
QUINQUELOCULINA CARINATA-STRIATA										1										
QUINQUELOCULINA GOESI		2																		
QUINQUELOCULINA GUALTIERIANA																				
QUINQUELOCULINA IMPRESSA	2	22	28	19	9	214	6	7	5	16	1	4		15	1	20	27	4	10	92
QUINQUELOCULINA POEYANA				1						1										1
QUINQUELOCULINA SEMINULA	48	28	35	75	2	5	2	6	7	18	1		9	36	2	1	3	3		24
QUINQUELOCULINA CF. Q. STRIATA																				
QUINQUELOCULINA TENAGOS		2		1																
QUINQUELOCULINA SP. A																				
REOPHAX NANA																				
ROSALINA BULBOSA														1						1
ROSALINA CONCINNA																				
ROSALINA FLORIDANA												1								
ROSALINA AFF. A. FLORIDENSIS																				
ROSALINA GLOBULARIS			2					1			1		7							2
ROSALINA SUBARAUCANA																				
ROSALINA JUVENILES																				
SCUTULORIS SP. A				1																1
SIGMAVIRGULINA TORTUOSA																				
SORITES MARGINALIS																				
SPIROLOCULINA DEPRESSA																				
STETSONIA MINUTA																				
TRIFARINA OCCIDENTALIS															2					
TRILOCULINA CF. T. TRIGONULA																				
TROCHAMMINA CF. T. ADVENA												1								
TROCHAMMINA OCHRACEA																				
TROCHAMMINA SP A																				
? TUBINELLA SP. A																				
WEISNERELLA AURICULATA																				
TOTAL	173	114	134	137	57	316	75	87	169	166	176	138	300	411	312	65	70	110	32	202

VERO BEACH										LINKPORT						JIM'S FLAT				BUOY 195									
1	1'	2	2'	3	3'	4	4'	5	5'	1	1'	2	2'	3	3'	1	2	3	4	1	1'	2	2'	3	3'	4	4'	5	5'
																1		1	1										
16	58	135	233	55	31	110	69	120	76	108	113	59	101	24	10	58	45	157	52	141	377	96	220	46	143	103	131	323	194
																									1			4	
				1		1	2	2									1	9	12		1				2	3			23
						1			4																4	4			
													1																
													1												3		1		
	1	28	57	6	1	18	4	3	6	14	14	7	23	15	3	16	4	14	4	33	38	18	38	6	74	131	101	25	41
			2	1																4	6	1				1	3	2	
																										3			
			1	1																			2		4	6			
																													1
	1	1	2	5	2	4	3	2	1	5	6	2	12	1	1	17	3	25	7	10	25	13	25	4	60	92	62	8	4
																										1			
																					2								
																3	16	67	2										
																						1							
						1							1																
																											1		
											1		3	1		4										1			
		2	1		2	8	2	3	10	14	5	3	10	2			3	5	1	8	26	1	11		26	1	4	8	
	2							1																	3				
5	14	3	3	37	1	53	6	50	48	20	17	1	6	1	2					1		1		1	3		6		
		2			1			12	8							3		5	6						1			11	18
5	52	3		2				20	24	2			4		1	9	1	20	11	1	2		1	1	1	2	2	1	4
																										2			
																	1	1			2	1	1		1				
																						1							
5			1			1		2	2								5	2											
			1																						2				
																							1		1	3	3		
																										2			
1	1						1	1	1									5		8	11			2	8	9		19	26
																									3				
	3						1	3	1		2					1					1		1						
		5	2	1	1	2	2		1				1				1												
																						1				1	3		2
																	67	6	5										
																			1										
			1		1	4		1							1														
																						1	1			2			
		1																										4	
							1			3	1	3	6	1		8	2	6	10			2	3	1	15	15	19		6
																										2			
																1													
								2	1							2		1			1								
																		3		1									
																	2												
			1					1					1							2									
5	15	35	35	18	1	15	2	13	9	2	2			1		4	26	42	38	4	3			1	3				
			1	1									1					3	1		1								
13	7	10	10	2	1	6	3	32	17	5	1	2	2	5	2	52	21	81	23	4	15	1	7	1	7	13	7		3
																										1			
																	1		1										
																		2			2		1			5	1		
	1								1				1					1					1				1		
		5	1								1		6	5								7				3	1		
		21	39									3	10	17	3					1	9	4	2						
		1	2																										
	2	8	9	1						1	1	1	2		1			3	2		1	3	8		5		4		
						1		4	14												1								
			1																	2	5					2		1	1
																						1							
											1																		
																				2	4				1				1
														1						1					3				1
																										3			
																	1	3											
50	157	260	403	131	42	225	96	272	224	174	165	81	192	74	24	179	200	462	177	223	533	153	323	63	374	411	350	406	325

SPECIES	HERMAN'S BAY 1	1'	2	2'	3	3'	4	4'	5	5'	JENSEN BEACH 1	1'	2	2'	3	3'	4	4'	5	5'
? ALLOGROMIA				3			2							2						
AMMONIA BECCARII	196	69	30	26	106	119	59	68	45	41	12	91	8	31		21	53	59	7	34
AMMOBACULITES EXIGUUS																				
AMMOBACULITES EXILIS												3	1				1	3		
AMMOBACULITES CF. A. EXILIS				11	4		20	17	1			3								
ARTICULINA CF. A. PACIFICA																I				
BILOCULINELLA GLOBULA			2						4	1					1	1				
BOLIVINA CF. B. COMPACTA																				
BOLIVINA PAULA				1	1		1							1						
BOLIVINA STRIATULA	6	2	97	150	45	29	271	127	136	7		19	2	35	1	3	49	49	4	
BOLIVINA SUBEXCAVATA			1	2	2													1		
BOLIVINA SP. A																				
BOLIVINA SP. B				3	1	2	3		4					4				1		
BULIMINA ACCULEATA			1	2	5	1														
BULIMINELLA ELEGANTISSIMA	3		8	14	18	10	98	39	26	1			2	8	3	1	15	19	2	
CASSIDULINA BARBARA																				
CIBICIDES AFF. C. FLORIDANA																			1	
CIBICIDES SP																				
CYCLOGYRA PLANORBIS	1								1											
CYMBALOPORETTA ATLANTICA	1																			
CYMBALOPORETTA SP. A									1											
EDENTOSTOMINA CULTRATA							1		1											
EDENTOSTOMINA CF. E. CULTRATA																				
ELPHIDIUM ADVENUM	1				1	2	1					5				1				2
ELPHIDIUM EXCAVATUM	2					1			5	1			3				2			1
ELPHIDIIUM GALVESTONENSE	3	1																		
ELPHIDIUM GUNTERI	1		1	2	3	2	1	7			1	11		1						
ELPHIDIUM KUGLERI									9	2										
ELPHIDIUM MEXICANUM	1	1			2				1		1	13	1					6	3	
ELPHIDIUM CF. E. MEXICANUM																				
ELPHIDIUM NORVANGI							1						1	1						
ELPHIDIUM SP. A							1													
EPONIDES REPANDUS																				
FISSURINA LUCIDA									1			1		2						
FISSURINA SP. A																				
FURSENKOINA FUSIFORMIS					2	1		1	2	3							6			
FURSENKOINA MEXICANA							7	1						1				1		
FURSENKOINA PONTONI																				
GAUDRYINA EXILIS								2				2	1	3			7	3		
GLABRATELLA SP.																				
GLABRATELLINA SAGRAI	1						3	1				1					1			
HANZAWAIA CONCENTRICA																		1		
HAYNESINA GERMANICA			1		1					2										
HOPKINSINA PACIFICA				2	6	2	6	3	3					13	1		9	17		
HOPKINSINA CF. H. PACIFICA													1					1		
ISHAMELLA APERTURA																				
LAGENA CF. L. DOVEYENSIS			1	3			2	1						2						
MASSILINA SP. A																				
MILIOLINELLA SUBROTUNDA															1					
MILIOLINELLA CF. M. SUBROTUNDA																				
? MILIOLINELLA SP. A																				
MYCHOSTOMINA REVERTENS						1														
NONION BOUEANUM						1		2												
NONION SP.							3													
NONIONELLA ATLANTICA																				1
NONIONELLA AURICULA			10	31	4	4	59	29	23	4		3	2	2	3	1	10	18	1	
NONIONELLA CF. N. AURICULA									1											
NONIONELLA OPIMA					1				1					I			3	1		
PAETEORIS DILITATA																				
? PAVONINA SP.																				
PENEROPLIS PERTUSUS																				
PLANORBULINA MEDITERRANENSIS																				
QUINQUELOCULINA AGGLUTINANS	1											3								
QUINQUELOCULINA CF. Q. AKNERIANA				1											1	4				
QUINQUELOCULINA CF. Q. BIDENTATA				2					5					2						
QUINQUELOCULINA CARINATA-STRIATA	1																			
QUINQUELOCULINA GOESI	1		3	2					5	1						1				
QUINQUELOCULINA GUALTIERIANA																				
QUINQUELOCULINA IMPRESSA	51		5		2		1		10	2		30	15	2	2	3		1		3
QUINQUELOCULINA POEYANA	11			4			1					6				1	1	1		
QUINQUELOCULINA SEMINULA	33	1	14	22	3		21	2	22	6	1	49	9	7	4	4	5	9		1
QUINQUELOCULINA CF. Q. STRIATA											1									
QUINQUELOCULINA TENAGOS	3																			
QUINQUELOCULINA SP. A																2				
REOPHAX NANA												1								
ROSALINA BULBOSA	1		1			1						1				1				
ROSALINA CONCINNA				1								2					6			
ROSALINA FLORIDANA	4			2					2			8		2			2			
ROSALINA AFF. A. FLORIDENSIS																				
ROSALINA GLOBULARIS		2			2		2	1				10		2					2	1
ROSALINA SUBARAUCANA												1								
ROSALINA JUVENILES			1																	
SCUTULORIS SP. A	4																			
SIGMAVIRGULINA TORTUOSA																				
SORITES MARGINALIS																				
SPIROLOCULINA DEPRESSA												1								
STETSONIA MINUTA																				
TRIFARINA OCCIDENTALIS																				
TRILOCULINA CF. T. TRIGONULA	7														1					
TROCHAMINA CF. T. ADVENA												1								
TROCHAMINA OCHRACEA												2						1		
TROCHAMINA SP A																				
? TUBINELLA SP. A																				
WEISNERELLA AURICULATA																				
TOTAL	333	76	176	284	209	176	564	301	309	71	16	267	46	122	18	45	170	192	20	43

SPECIES	ST. LUCIE TRANSECT 1	1'	2	2'	3	3'	4	4'	5	5'	ST. LUCIE INLET 1	2	3	4
? ALLOGROMIA......................														
AMMONIA BECCARII..................	395	499	18	10	11	11	246	139	7	4	24	143	78	54
AMMOBACULITES EXIGUUS.............							1							
AMMOBACULITES EXILIS..............							2					1		
AMMOBACULITES CF. A. EXILIS.......														
ARTICULINA CF. A. PACIFICA........														
BILOCULINELLA GLOBULA.............														
BOLIVINA CF. B. COMPACTA..........														
BOLIVINA PAULA....................		1	1			1	11	5				1	3	
BOLIVINA STRIATULA................	50	63	4		2		92	107		1	12	17	41	23
BOLIVINA SUBEXCAVATA..............	1	1				1	3	3				5	2	
BOLIVINA SP. A....................														
BOLIVINA SP. B....................		1												
BULIMINA ACCULEATA................							2	1						
BULIMINELLA ELEGANTISSIMA.........	37	46					108	54			3	51	109	118
CASSIDULINA BARBARA...............							1							
CIBICIDES AFF. C. FLORIDANA.......												3		
CIBICIDES SP......................														
CYCLOGYRA PLANORBIS...............	1	1					4				8	6	16	
CYMBALOPORETTA ATLANTICA..........														
CYMBALOPORETTA SP. A..............														
EDENTOSTOMINA CULTRATA............		1												
EDENTOSTOMINA CF. E. CULTRATA.....														
ELPHIDIUM ADVENUM.................							6	2				2	2	
ELPHIDIUM EXCAVATUM...............	2	1			1	5	11	1				49	20	1
ELPHIDIIUM GALVESTONENSE..........														
ELPHIDIUM GUNTERI.................	1												1	
ELPHIDIUM KUGLERI.................	1	2					3				2			10
ELPHIDIUM MEXICANUM...............	74	53			9		15	11		2	12	10	25	16
ELPHIDIUM CF. E. MEXICANUM........														
ELPHIDIUM NORVANGI................											1			2
ELPHIDIUM SP. A...................														
EPONIDES REPANDUS.................				1					2			2		1
FISSURINA LUCIDA..................		4												
FISSURINA SP. A...................		1												
FURSENKOINA FUSIFORMIS............							1							
FURSENKOINA MEXICANA..............														
FURSENKOINA PONTONI...............								1				1		
GAUDRYINA EXILIS..................	10	3	1			1	17	7			1	1		
GLABRATELLA SP....................														
GLABRATELLINA SAGRAI..............	1	2					1		1					
HANZAWAIA CONCENTRICA.............		1							1	1		2		
HAYNESINA GERMANICA...............							3		1		1			1
HOPKINSINA PACIFICA...............							1							
HOPKINSINA CF. H. PACIFICA........														
ISHAMELLA APERTURA................											1			
LAGENA CF. L. DOVEYENSIS..........								1						
MASSILINA SP. A...................														
MILIOLINELLA SUBROTUNDA...........														
MILIOLINELLA CF. M. SUBROTUNDA....														
? MILIOLINELLA SP. A..............				1										
MYCHOSTOMINA REVERTENS............	1													
NONION BOUEANUM...................														
NONION SP.........................														
NONIONELLA ATLANTICA..............									3					
NONIONELLA AURICULA...............	37	46					8	23			3	4	7	3
NONIONELLA CF. N. AURICULA........														
NONIONELLA OPIMA..................														
PAETEORIS DILITATA................											3			
? PAVONINA SP.....................												1		
PENEROPLIS PERTUSUS...............											2	3	1	1
PLANORBULINA MEDITERRANENSIS......												1		
QUINQUELOCULINA AGGLUTINANS.......							1						1	
QUINQUELOCULINA CF. Q. AKNERIANA..		1	4						4					
QUINQUELOCULINA CF. Q. BIDENTATA..														
QUINQUELOCULINA CARINATA-STRIATA..											1			
QUINQUELOCULINA GOESI.............														
QUINQUELOCULINA GUALTIERIANA......											2			
QUINQUELOCULINA IMPRESSA..........	28	11	1				1		4	2	6		5	
QUINQUELOCULINA POEYANA...........		1					5	2			1		1	
QUINQUELOCULINA SEMINULA..........	90	192	2	6		1	70	20	4	2	7	7	20	5
QUINQUELOCULINA CF. Q. STRIATA....														
QUINQUELOCULINA TENAGOS...........														
QUINQUELOCULINA SP. A.............														
REOPHAX NANA......................							7							
ROSALINA BULBOSA..................							1							
ROSALINA CONCINNA.................	6													
ROSALINA FLORIDANA................	2	4	5	3	1		6		1		1	5		1
ROSALINA AFF. A. FLORIDENSIS......														
ROSALINA GLOBULARIS...............	27	4	5	1	1		7				3	6	4	
ROSALINA SUBARAUCANA..............			1				8	2						
ROSALINA JUVENILES................		1			2									
SCUTULORIS SP. A..................		1		2								1		
SIGMAVIRGULINA TORTUOSA...........		1												
SORITES MARGINALIS................							2							3
SPIROLOCULINA DEPRESSA............														
STETSONIA MINUTA..................													1	1
TRIFARINA OCCIDENTALIS............	2					1	1			2			1	
TRILOCULINA CF. T. TRIGONULA......		1												
TROCHAMINA CF. T. ADVENA..........				1										
TROCHAMINA OCHRACEA...............				1					8	7				
IROCHAMINA SP A...................														
? TUBINELLA SP. A.................														
WEISNERELLA AURICULATA............	1	1	4	1		2			3	5				
TOTAL.............................	767	944	46	27	27	23	645	379	39	26	94	322	338	240

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PLATE 1

(Micrographs reduced to 52.5%)

Reophax nana Rhumbler
1. Side view, hypotype, USNM 310285, × 205.

Ammobaculites exigiuus Cushman and Bronniman
2. Side view, hypotype, USNM 310280, × 195.
3. Apertural view, hypotype, USNM 310280, × 350.

Ammobaculites exilis Cushman and Bronniman
4. Side view, hypotype, USNM 310281, × 90.
5. Apertural view, hypotype, USNM 310281, × 190.

Ammobaculites cf. *exilis* Cushman and Bronniman
6. Side view, figured specimen, USNM 310282, × 60.
7. Apertural view, figured specimen, USNM 310282, × 95.

Trochamina cf. *advena* Cushman
8. Spiral side, figured specimen, USNM 310286, × 475.
9. Umbilical side, figured specimen, USNM 310286, × 500.

Trochamina ochracea (Williamson)
10. Spiral side, hypotype, USNM 310287, × 540.
11. Umbilical side, hypotype, USNM 310287, × 540.

Gaudryina exilis Cushman and Bronniman
12. Side view, hypotype, USNM 310283, × 155.
13. Side view, hypotype, USNM 310284, × 395.

Cyclogyra planorbis (Schultze)
14. Side view, hypotype, USNM 310247, × 220.

Edentostomina cultrata (Brady)
15. Side view, hypotype, USNM 310248, × 80.
16. Apertural view, hypotype, USNM 310248, × 105.

Weisnerella auriculata (Egger)
17. Side view, hypotype, USNM 310279, × 300.

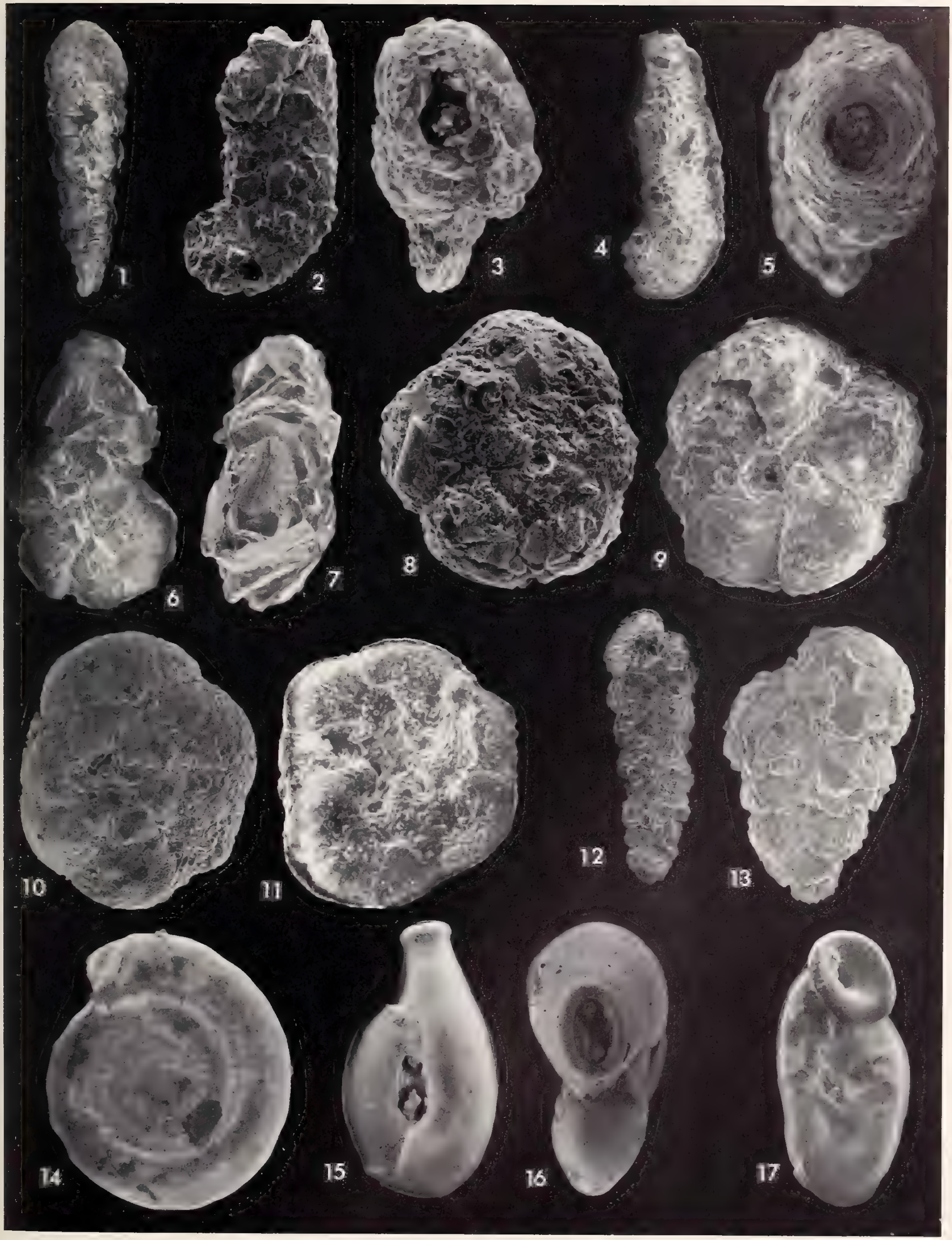
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PLATE 2

(Micrographs reduced to 52.5%)

Spiroloculina depressa d'Orbigny
1. Side view, hypotype, USNM 310276, × 60.
2. Apertural view, hypotype, USNM 310276, × 95.

Quinqueloculina agglutinans d'Orbigny
3. Side view, hypotype, USNM 310260, × 215.
4. Apertural view, hypotype, USNM 310260, × 380.
5. Side view, hypotype, USNM 310261, × 215.
6. Apertural view, hypotype, USNM 310261, × 390.

Quinqueloculina cf. akneriana d'Orbigny
7. Side view, figured specimen, USNM 310262, × 105.
8. Apertural view, figured specimen, USNM 310262, × 160.

Quinqueloculina cf. *bidentata* d'Orbigny
9. Side view, figured specimen, USNM 310263, × 160.
10. Apertural view, figured specimen, USNM 310263, × 275.

Quinqueloculina carinata-striata (Weisner)
11. Edge view, hypotype, USNM 310264, × 235.
12. Apertural view, hypotype, USNM 310264, × 400.
13. Side view, hypotype, USNM 310264, × 240.

Quinqueloculina goesi (Weisner)
14. Side view, hypotype, USNM 310265, × 100.
15. Apertural view, hypotype, USNM 310265, × 185.
16. Side view, hypotype, USNM 310266, × 90.
17. Apertural view, hypotype, USNM 310266, × 160.


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PLATE 3

(Micrographs reduced to 52.5%)

Quinqueloculina gualtieriana d'Orbigny
1. Side view, hypotype, USNM 310267, × 230.
2. Apertural view, hypotype, USNM 310267, × 300.

Quinqueloculina impressa Reuss
3. Side view, hypotype, USNM 310268, × 210.
4. Apertural view, hypotype, USNM 310268, × 295.

Quinqueloculina poeyana d'Orbigny
5. Side view, hypotype, USNM 310269, × 325.
6. Apertural view, hypotype, USNM 310269, × 550.

Quinqueloculina seminula (Linné)
7. Side view, hypotype, USNM 310270, × 170.
8. Apertural view, hypotype, USNM 310270, × 300.

Quinqueloculina cf. *striata* d'Orbigny
9. Side view, figured specimen, USNM 310271, × 145.
10. Apertural view, figured specimen, USNM 310271, × 270.

Quinqueloculina tenagos Parker
11. Side view, hypotype, USNM 310272, × 165.
12. Apertural view, hypotype, USNM 310272, × 280.

Quinqueloculina species
13. Side view, figured specimen, USNM 310273, × 120.
14. Apertural view, figured specimen, USNM 310273, × 170.

?*Massilina* species
15. Side view, figured specimen, USNM 310249, × 80.
16. Apertural view, figured specimen, USNM 310249, × 100.

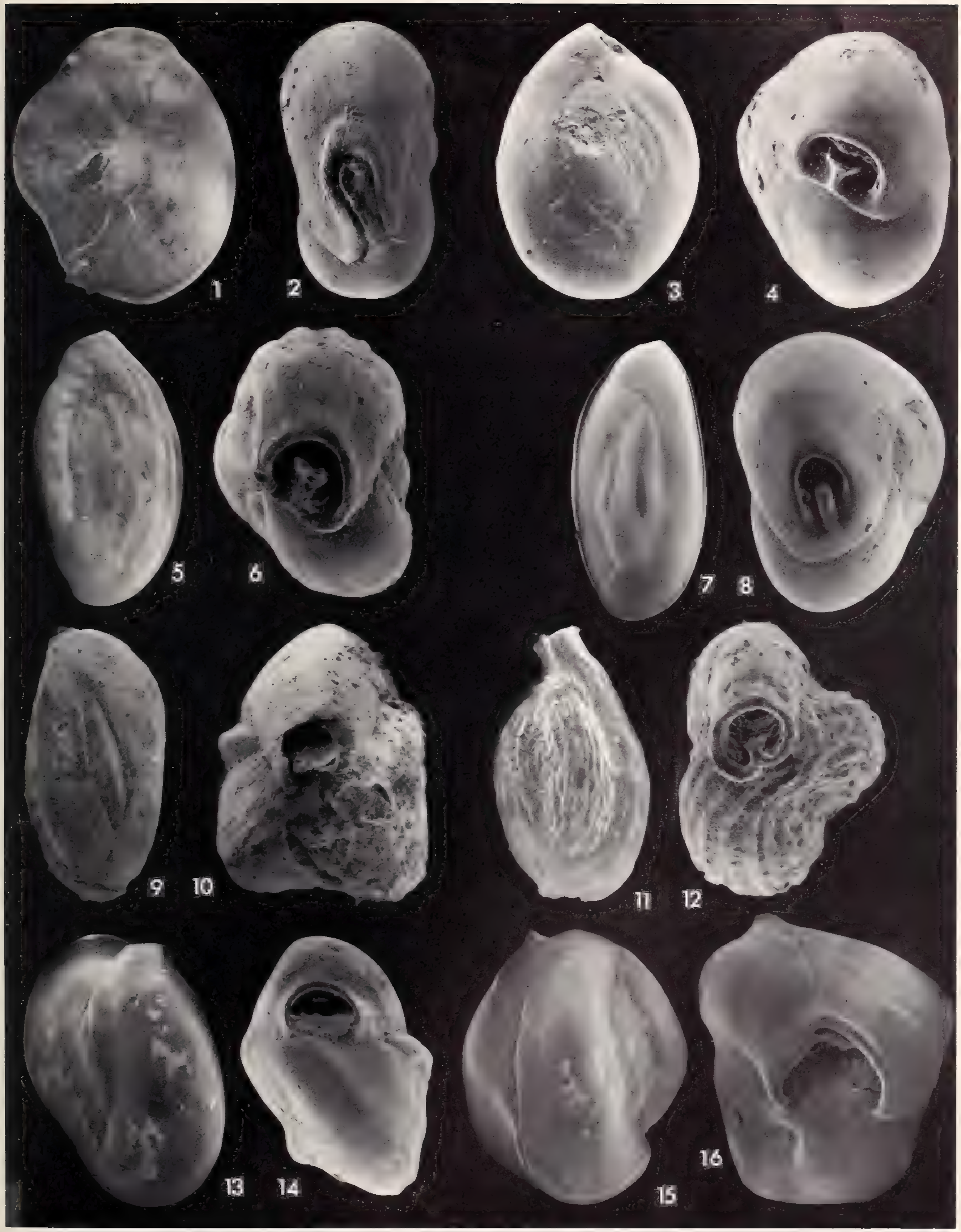
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PLATE 4

(Micrographs reduce to 52.5%)

Paeteoris dilitata (d'Orbigny)
1. Side view, hypotype, USNM 310258, × 310.
2. Apertural view, hypotype, USNM 310258, × 320.

Trioculina cf. *trigonula* (Lamarck)
3. Side view, figured specimen, USNM 310277, × 160.
4. Apertural view, figured specimen, USNM 310277, × 220.

Miliolinella subrotunda (Montagu)
5. Side view, hypotype, USNM 310250, × 200.
6. Apertural view, hypotype, USNM 310250, × 210.

Miliolinella cf. *subrotunda* (Montagu)
7. Side view, figured specimen, USNM 310256, × 250.
8. Apertural view, figured specimen, USNM 310256, × 260.

?Miliolinella species
9. Side view, figured specimen, USNM 310257, × 250.
10. Apertural view, figured specimen, USNM 310257, × 185.

Biloculinella globula (Bornemann)
11. Side view, hypotype, USNM 310246, × 175.
12. Apertural view, hypotype, USNM 310246, × 200.

Scutuloris species
13. Side view, figured specimen, USNM 310274, × 205.
14. Apertural view, figured specimen, USNM 310274, × 260.

?Tubinella species
15. Side view, figured specimen, USNM 310278, × 280.

Articulina cf. *pacifica* Cushman
16. Side view, figured specimen, USNM 310245, × 120.


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PLATE 5

(Micrographs reduced to 52.5%)

Peneroplis pertusus (Forskål)
1. Side view, hypotype, USNM 310259, × 220.

Lagena cf. *doveyensis* Haynes
2. Side view, figured specimen, USNM 310182, × 230.

Fissurina lucida (Williamson)
3. Side view, hypotype, USNM 310183, × 565.

Fissurina species
4. Side view, figured specimen, USNM 310184, × 390.

Buliminella elegantissima (d'Orbigny)
5. Side view, hypotype, USNM 310214, × 260.

Bolivina cf. *compacta* Sidebottom
6. Side view, figured specimen, USNM 310192, × 215.

Bolivina paula Cushman and Cahill
7. Side view, hypotype, USNM 310193, × 250.

Bolivina striatula Cushman
8. Side view, hypotype, USNM 310194, × 110.

Bolivina subexcavata Cushman and Wickenden
9. Side view, hypotype, USNM 310195, × 330.

Bolivina sp. A
10. Side view, figured specimen, USNM 310196, × 180.

Bolivina sp. B
11. Side view, figured specimen, USNM 310197, × 170.

Bulimina acculeata d'Orbigny
12. Side view, hypotype, USNM 310209, × 425.

?Pavonina species
13. Side view, figured specimen, USNM 310233, × 210.

Hopkinsina pacifica Cushman
14. Side view, hypotype, USNM 310190, × 275.

Hopkinsina cf. *pacifica* Cushman
15. Side view, figured specimen, USNM 310191, × 245.

Trifarina occidentalis (Cushman)
16. Side view, hypotype, USNM 310210, × 195.

Rosalina bulbosa (Parker)
17. Spiral side, hypotype, USNM 301234, × 520.
18. Umbilical side, hypotype, USNM 301234, × 490.
19. Side view, attached to *Quinqueloculina impressa* Reuss, USNM 310235, × 550.

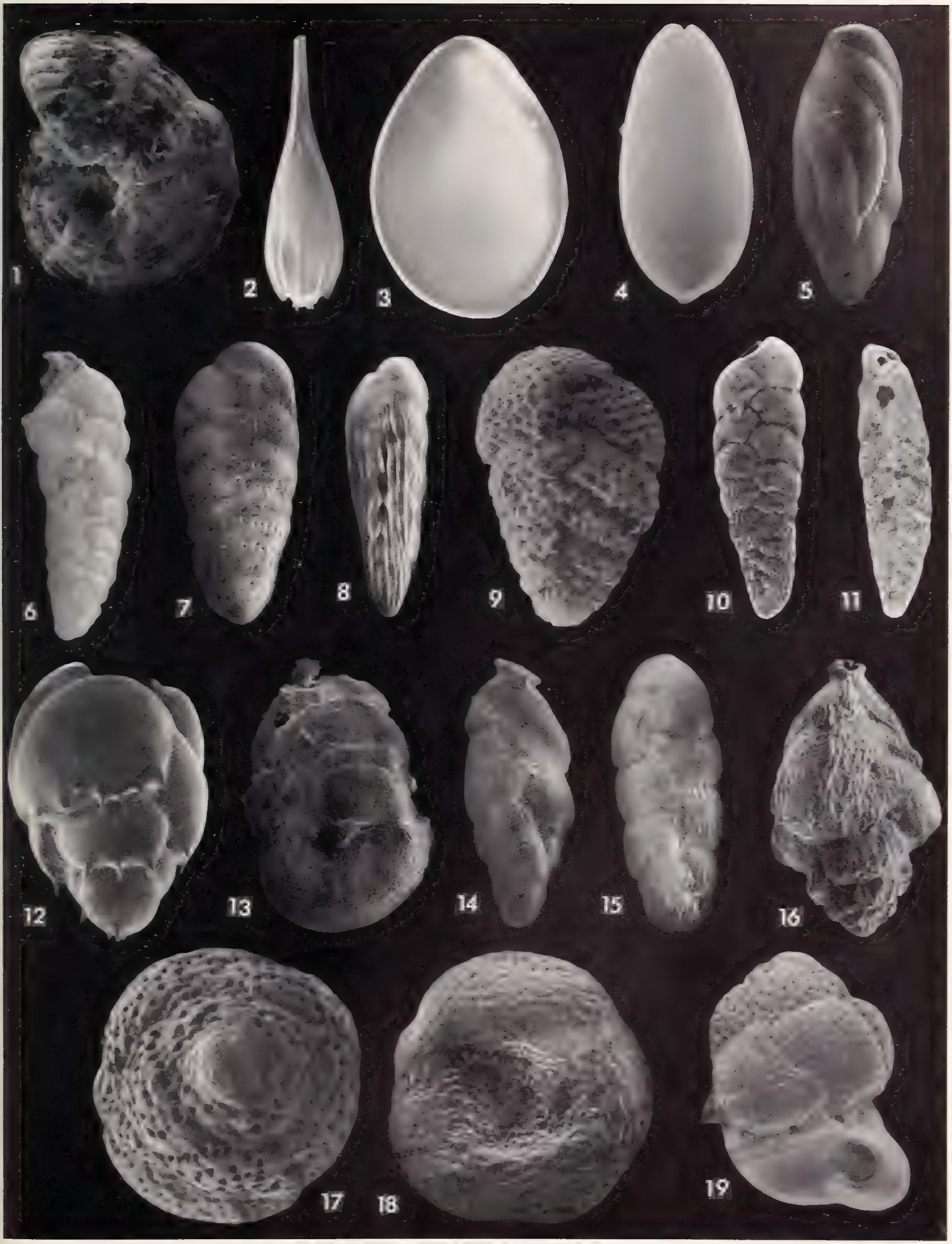
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PLATE 6

(Micrographs reduced to 52.5%)

Rosalina concinna (Brady)

1. Spiral side, hypotype, USNM 310237, × 290.
2. Umbilical side, hypotype, USNM 310237, × 290.

Rosalina aff. *floridensis* (Cushman)

3. Spiral side, figured specimen, USNM 310239, × 225.
4. Umbilical side, figured specimen, USNM 310239, × 225.

Rosalina floridana (Cushman)

5. Spiral side, hypotype, USNM 310238, × 230.
6. Umbilical side, hypotype, USNM 310238, × 250.

Rosalina globularis d'Orbigny

7. Spiral side, hypotype, USNM 310240, × 285.
8. Umbilical side, hypotype, USNM 310240, × 255.

Rosalina subaraucana (Cushman)

9. Umbilical side, hypotype, USNM 310243, × 355.
10. Spiral side, hypotype, USNM 310243, × 375.
11. Umbilical side, hypotype, USNM 310242, × 195.
12. Spiral side, hypotype, USNM 310242, × 175.

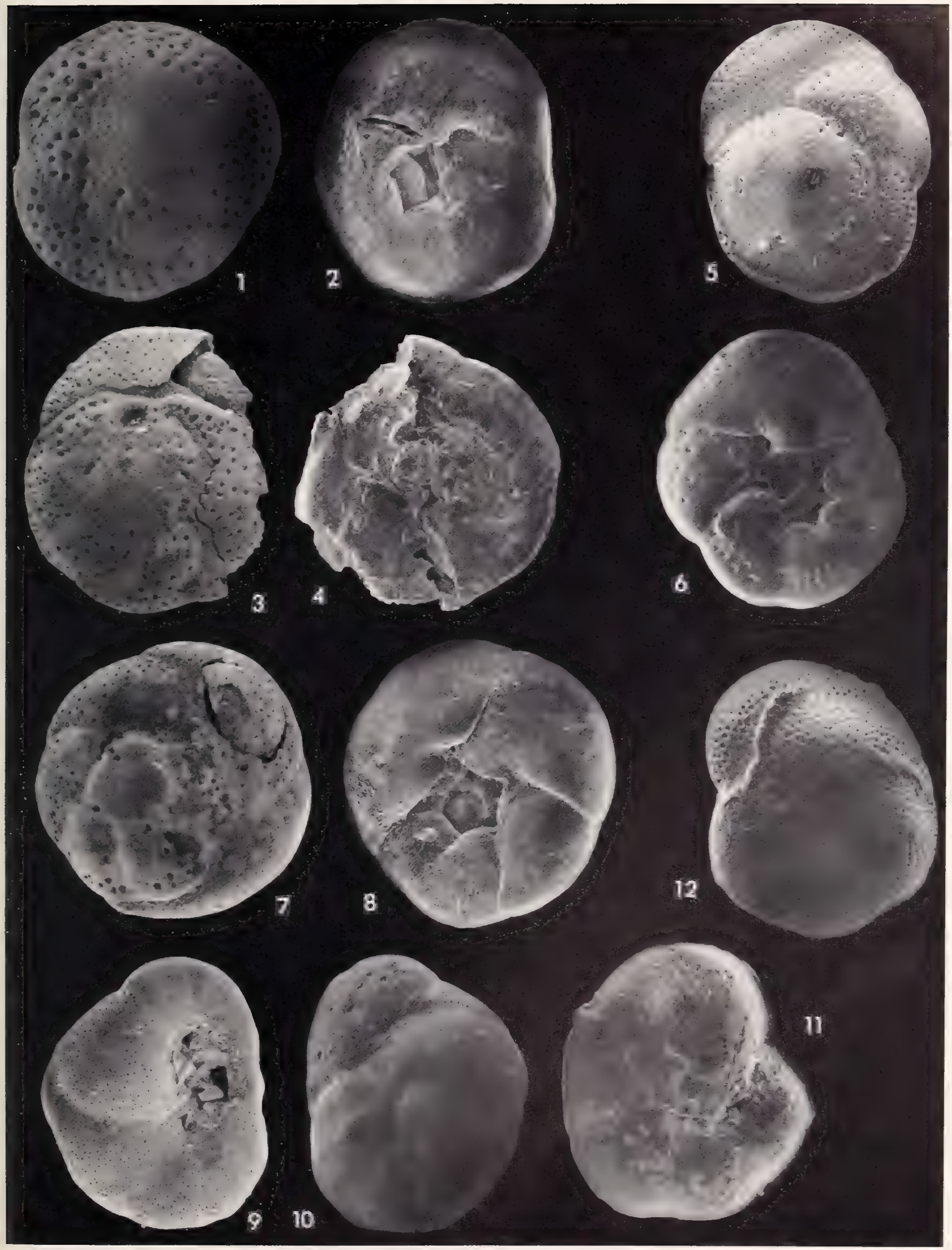
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PLATE 7

(Micrographs reduced to 52.5%)

Stetsonia minuta Parker
1. Spiral side, hypotype, USNM 310244, × 450.
2. Umbilical side, hypotype, USNM 310244, × 450.

Glabratella species
3. Spiral side, figured specimen, USNM 310220, × 440.
4. Umbilical side, figured specimen, USNM 310220, × 455.

Glabratellina sagrai (Todd and Bronniman)
5. Spiral side, hypotype, USNM 310221, × 360.
6. Umbilical side, hypotype, USNM 310221, × 375.

Mychostomina revertens (Rhumbler)
7. Spiral side, hypotype, USNM 310223, × 165.
8. Umbilical side, hypotype, USNM 310223, × 165.

Ammonia beccarii (Linné)
9. Umbilical side, hypotype, USNM 310213, × 200.
10. Spiral side, hypotype, USNM 310213, × 205.


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PLATE 8

(Micrographs reduced to 52.5%)

Elphidium advenum (Cushman)
1. Side view, hypotype, USNM 310198, × 255.

Elphidium excavatum (Terquem)
2. Side view, hypotype, USNM 310202, × 215.

Elphidium galvestonense (Kornfeld)
3. Side view, hypotype, USNM 310200, × 105.

Elphidium gunteri Cole
4. Side view, hypotype, USNM 310203, × 205.

Elphidium kugleri (Cushman and Bronniman)
5. Side view, hypotype, USNM 310205, × 130.

Elphidium mexicanum Kornfeld
6. Side view, hypotype, USNM 310288, × 240.

Elphidium cf. *mexicanum* Kornfeld
7. Side view, figured specimen, USNM 310207, × 180.

Elphidium norvangi Buzas, Smith, and Beem
8. Side view, hypotype, USNM 310206, × 485.

Elphidium species
9. Side view, figured specimen, USNM 310208, × 135.

Haynesina germanica (Ehrenberg)
10. Side view, hypotype, USNM 310211, × 225.


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PLATE 9

(Micrographs reduced to 52.5%)

Eponides repandus (Fichtel and Moll)
1. Umbilical side, hypotype, USNM 310219, × 140.
2. Spiral side, hypotype, USNM 310219, × 130.

Cibicides aff. *floridana* (Cushman)
3. Spiral side, figured specimen, USNM 3102215, × 170.
4. Umbilical side, figured specimen, USNM 310215, × 180.

Cibicides species
5. Spiral side, figured specimen, USNM 310216, × 420.
6. Umbilical side, figured specimen, USNM 310216, × 440.

Planorbulina mediterranensis d'Orbigny
7. Spiral side, hypotype, USNM 310189, × 195.

Cymbaloporetta atlantica (Cushman)
8. Spiral side, hypotype, USNM 310217, × 240.
9. Umbilical side, hypotype, USNM 310217, × 250.

Cymbaloporetta species
10. Spiral side, figured specimen, USNM 310218, × 395.
11. Umbilical side, figured specimen, USNM 310218, × 410.

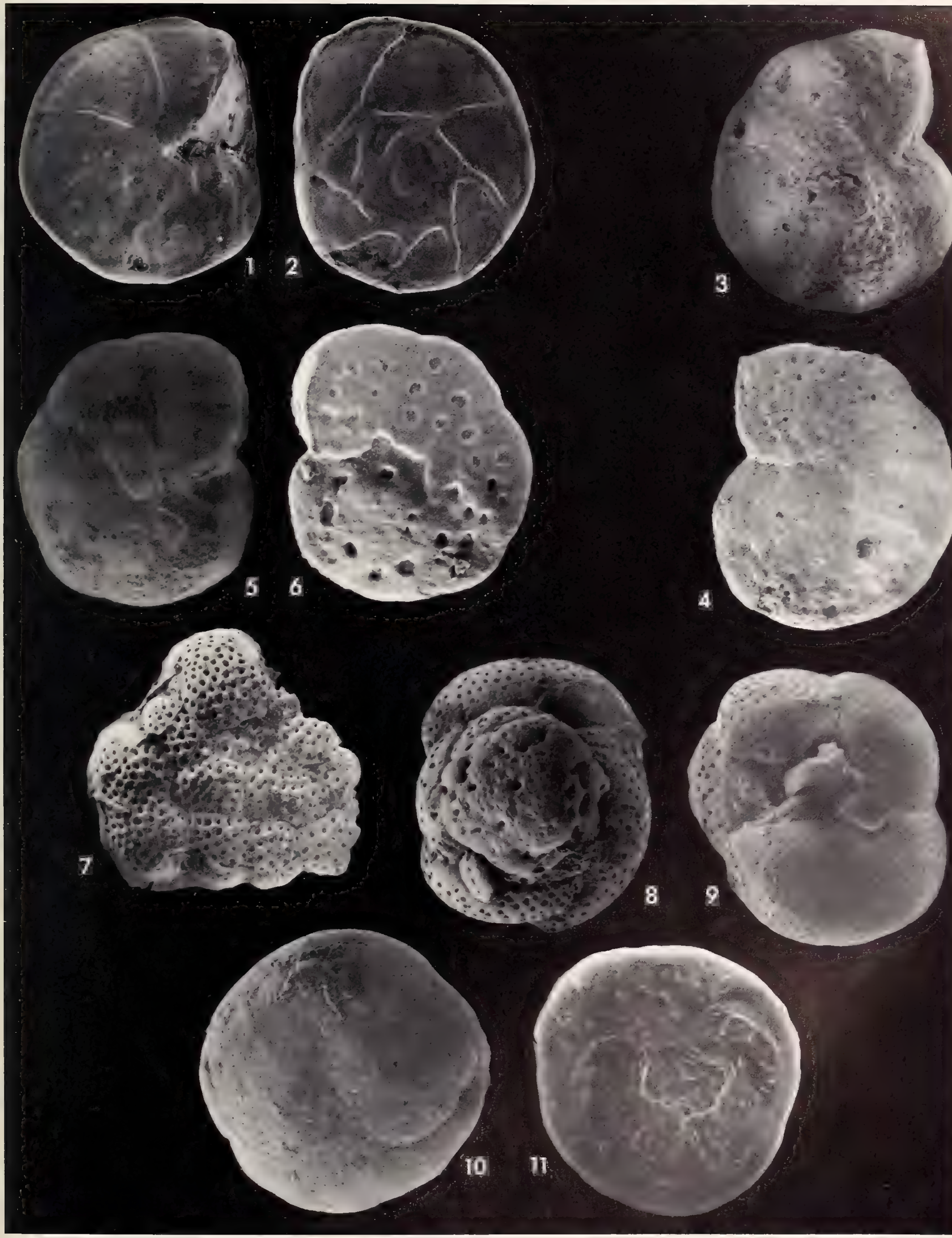
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PLATE 10

(Micrographs reduced to 53%)

Fursenkoina fusiformis (Williamson)
1. Side view, hypotype, USNM 310185, × 240.

Fursenkoina mexicana (Cushman)
2. Side view, hypotype, USNM 310186, × 215.

Fursenkoina pontoni (Cushman)
3. Side view, hypotype, USNM 310187, × 150.

Sigmavirgulina tortuosa (Brady)
4. Side view, hypotype, USNM 310188, × 350.

Cassidulina barbara Buzas
5. Side view, hypotype, USNM 310212, × 390.

Nonion boueanum (d'Orbigny)
6. Side view, hypotype, USNM 310224, × 90.
7. Peripheral view, hypotype, USNM 310244, × 90.

Nonion species
8. Peripheral view, figured specimen, USNM 310225, × 100.
9. Side view, figured specimen, USNM 310225, × 100.

Nonionella atlantica Cushman
10. Spiral side, hypotype, USNM 310227, × 130.
11. Peripheral view, hypotype, USNM 310227, × 130.
12. Involute side, hypotype, USNM 310227, × 130.


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PLATE 11

(Micrographs reduced to 53%)

Nonionella auricula Heron-Allen and Earland

1. Involute side, hypotype, USNM 310228, × 250.
2. Peripheral view, hypotype, USNM 310228, × 250.
3. Spiral side, hypotype, USNM 310228, × 250.

Nonionella cf. *auricula* Heron-Allen and Earland

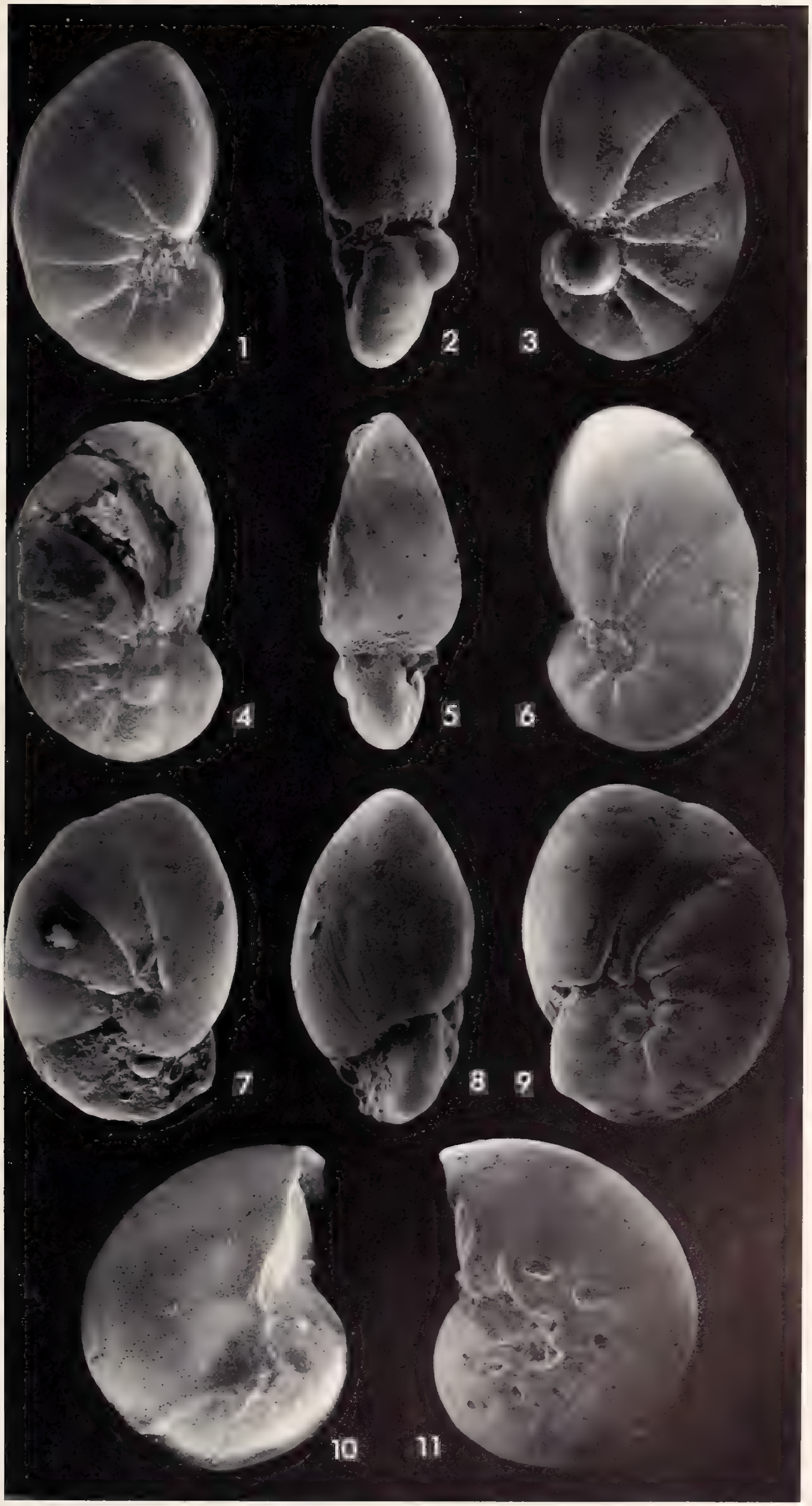
4. Spiral side, figured specimen, USNM 310230, × 210.
5. Peripheral view, figured specimen, USNM 310230, × 210.
6. Involute side, figured specimen, USNM 310230, × 210.

Nonionella opima Cushman

7. Spiral side, hypotype, USNM 310232, × 190.
8. Peripheral view, hypotype, USNM 310232, × 200.
9. Involute side, hypotype, USNM 310232, × 195.

Hanzawaia concentrica (Cushman)

10. Spiral side, hypotype, USNM 310222, × 165.
11. Umbilical side, hypotype, USNM 310222, × 165.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